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13. ABSTRACT *(Maximum 200 words)*

THIS FINAL TECHNICAL PLAN DESCRIBES THE WORK THAT WILL BE UNDERTAKEN TO PROVIDE THE TECHNICAL SERVICES NECESSARY TO CONDUCT THE TASK 44 WATER MONITORING PROGRAM. THE OBJECTIVES OF THE TASK ARE TO:

1. ASSESS THE DISTRIBUTION AND CONCENTRATION LEVELS OF GROUND AND SURFACE WATER CONTAMINANTS BOTH ON AND OFF POST
2. MONITOR AND EVALUATE CHANGES IN WATER LEVELS
3. RECOMMEND PROGRAM MODIFICATIONS TO THIS OR OTHER WATER MONITORING TASKS
4. IDENTIFY AREAS OF SIGNIFICANT PUBLIC EXPOSURE AND MAKE APPROPRIATE INFORMATION AVAILABLE TO TASKS 35 AND 39.

TASK 44 WILL FORM THE BASE HYDROLOGIC PROGRAM, WHILE TASKS 25, 36, 38, AND 39 WILL BE BRANCH EFFORTS WHICH WILL SATISFY SPECIFIC INDIVIDUAL TASK NEEDS.

SECTIONS OF THIS PLAN DETAIL INFORMATION ON THE FOLLOWING PROGRAMS: CHEMICAL ANALYSIS, GEOTECHNICAL, QUALITY CONTROL, SAFETY, DATA MANAGEMENT, CONTAMINATION ASSESSMENT.

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LITIGATION TECHNICAL SUPPORT AND SERVICES

ROCKY MOUNTAIN ARSENAL

Final Technical Plan

March 1988
Contract Number DAAK11-84-D-0016
Task Number 44

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.

HARDING LAWSON ASSOCIATES MIDWEST RESEARCH INSTITUTE

PREPARED FOR

PROGRAM MANAGER'S OFFICE FOR ROCKY MOUNTAIN ARSENAL CLEANUP

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LITIGATION TECHNICAL SUPPORT AND SERVICES

Rocky Mountain Arsenal

Onpost/Offpost Ground/Surface Water Monitoring Program

Final Technical Plan

March 1988
Contract Number DAAK11-84-D-0016
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PREPARED BY

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.
HARDING LAWSON ASSOCIATES

PREPARED FOR

OFFICE OF THE PROGRAM MANAGER
ROCKY MOUNTAIN ARSENAL CONTAMINATION CLEANUP

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1.0 INTRODUCTION

1.1 LOCATION AND OPERATION SUMMARY

The Rocky Mountain Arsenal (RMA) occupies approximately 27 square miles (sq mi) in Adams County, Colorado, and is located 9 miles (mi) northeast of downtown Denver (Figure 1.1-1). RMA was established for manufacturing chemical and incendiary munitions and, in later years, for demilitarization (destruction) of chemical ordnance. Industrial chemicals were manufactured at RMA by several lessees from 1947 to 1982.

The majority of property occupied by RMA was purchased in 1942. Throughout World War II (WWII), chemical intermediate munitions, toxic end-item products, and incendiary munitions were manufactured and assembled at RMA.

From 1945 to 1950, RMA distilled stocks of Levinstein (H) mustard, demilitarized mustard-filled shells, and test-fired 107-millimeter (mm) mortar rounds filled with smoke and high explosives. Many different types of obsolete WWII ordnance were also destroyed by detonation or burning during that period.

In 1947, certain portions of RMA were leased to the Colorado Fuel and Iron Corporation (CF&I) for chemical manufacturing. CF&I manufactured chlorinated benzenes and dichlorodiphenyltrichloroethane (DDT). Julius Hyman and Company assumed the CF&I lease in 1950 and produced several pesticides. Shell Chemical Company (SCC) later assumed the pesticide and herbicide manufacturing operations and operated under the leases until 1982.

In the early 1950s, RMA was selected to produce the chemical nerve agent GB. The manufacturing facility was completed in 1953 and produced agents until 1957, with munitions filling operations continuing until late 1969. Since 1970, RMA has been involved primarily with the demilitarization of chemical warfare materials.

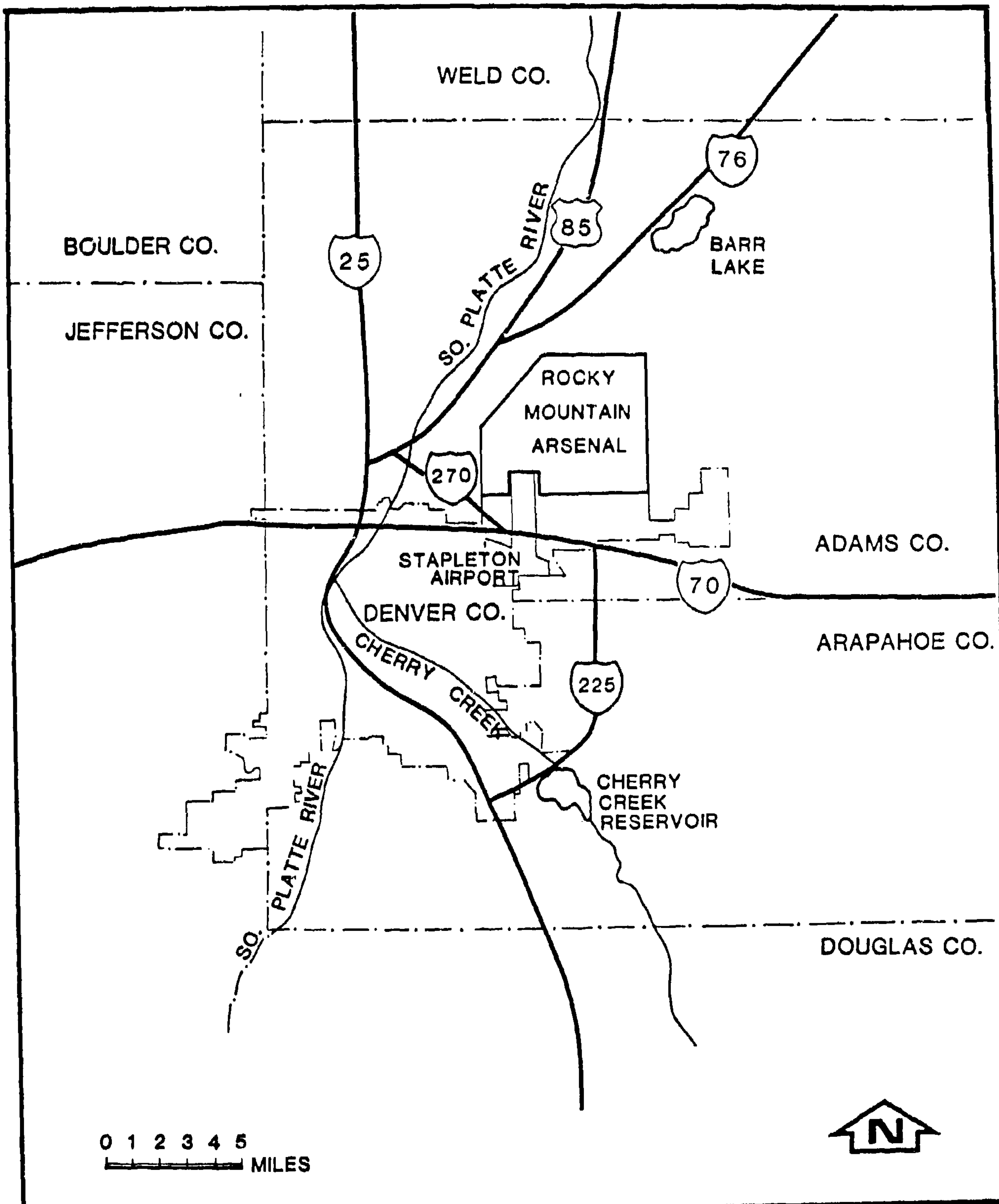

Figure 1.1-1
ROCKY MOUNTAIN ARSENAL
LOCATION MAP
SOURCE: RMA, 1983, ESE, 1987

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For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

Disposal practices at RMA have included routine discharge of industrial waste effluents to unlined evaporation basins and burial of solid wastes at various locations. In addition, unintentional spills of raw materials, process intermediates, and end products have occurred within the manufacturing complexes at RMA. Some of the compounds are mobile in surface and ground waters while others, such as pesticides, are much less mobile.

In 1954 and 1955, farmers northwest of RMA using well water for irrigation reported severe crop losses (HEW, 1965, RIC#85007R02). In 1974, two contaminants, diisopropylmethylphosphonate (DIMP), which is a by-product in the manufacture of the nerve agent Sarin (GB), and dicyclopentadiene (DCPD), a chemical used in insecticide production, were detected in offpost surface water. Since 1978, dibromochloropropane (DBCP), a nematocide shipped from RMA by rail from 1970 to 1975, has been identified in offpost ground water. In response to the detection of offsite contaminants, the State of Colorado issued a Cease and Desist Order in 1975 which required RMA to initiate a regional sampling and hydrologic surveillance program. The program required quarterly collection and analysis of over 100 onpost/offpost surface and ground water samples. From 1975 to the present date, various other programs have been implemented and are utilized for monitoring and surveillance of ground and surface water in order to satisfy operational and other regulatory requirements.

1.2 TASK 44 OBJECTIVES

As part of the environmental investigation at RMA, the necessity of establishing a comprehensive data base for surface and ground water has been recognized. Task 4 addressed part of this need by providing baseline data to assess contaminant distributions at RMA.

Under Task 4, three rounds of water samples were collected over a 1-year period within RMA to achieve the following objectives:

- o Satisfy compliance-oriented regulatory requirements under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the substantive requirements of all applicable or relevant and appropriate Federal and State requirements that have application through CERCLA;

- o Confirm the existence and chemical nature of contamination and monitor any changes in the lateral and vertical extent of contamination; and
- o Develop a core data base for use in upcoming litigation and Remedial Investigation/Feasibility Study analyses for RMA.

Task 44 was developed using the core Task 4 objectives, however, the scope of the task has been broadened to address other salient items that were beyond the scope of Task 4.

Figure 1.2-1 delineates the location of boundary containment systems and potential RMA contaminant sites. The interaction of specific tasks with Task 44 is illustrated in Figure 1.2-2.

Task 44 (under Contract No. DAAK-11-84-D-0016) was awarded on March 19, 1987. The objectives of Task 44 as detailed in the Delivery Order are to:

- o Assess the distribution and concentration levels of ground water and surface water contaminants and monitor changes in water quality with respect to these contaminants for both the onpost and offpost areas;
- o Monitor and evaluate changes in water levels;
- o Evaluate data and recommend program modifications to this or other water monitoring tasks; and
- o Identify areas of significant public exposure and make appropriate information available to Tasks 35 and 39.

In order to satisfy the primary goals of the task, certain ancillary objectives will be accomplished. Additionally, these efforts will further define the Task 44 scope-of-work (SOW):

- o Utilize available geologic data to further define the current understanding of the geologic conditions present at RMA;
- o Summarize the hydrogeologic conditions in the onpost and offpost areas by integrating existing hydrologic, geologic, and water quality data;
- o Identify the primary hydrogeologic pathways by which contaminants are being transported to the RMA boundary or the offpost area;

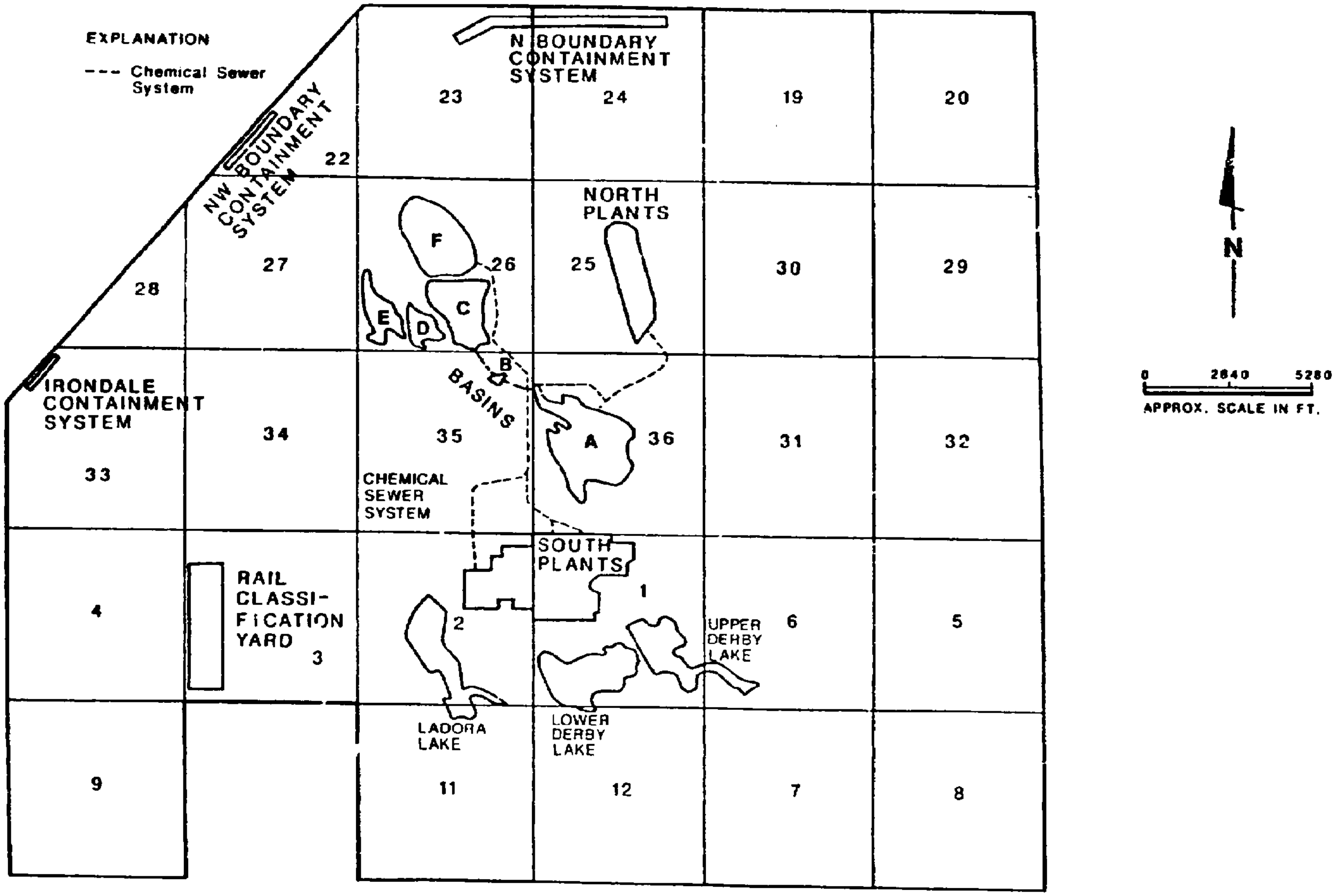

Figure 1.2-1
LOCATION OF MAJOR POTENTIAL CONTAMINANT SITES, LAKES AND CONTAINMENT SYSTEMS
SOURCE: HLA 1987

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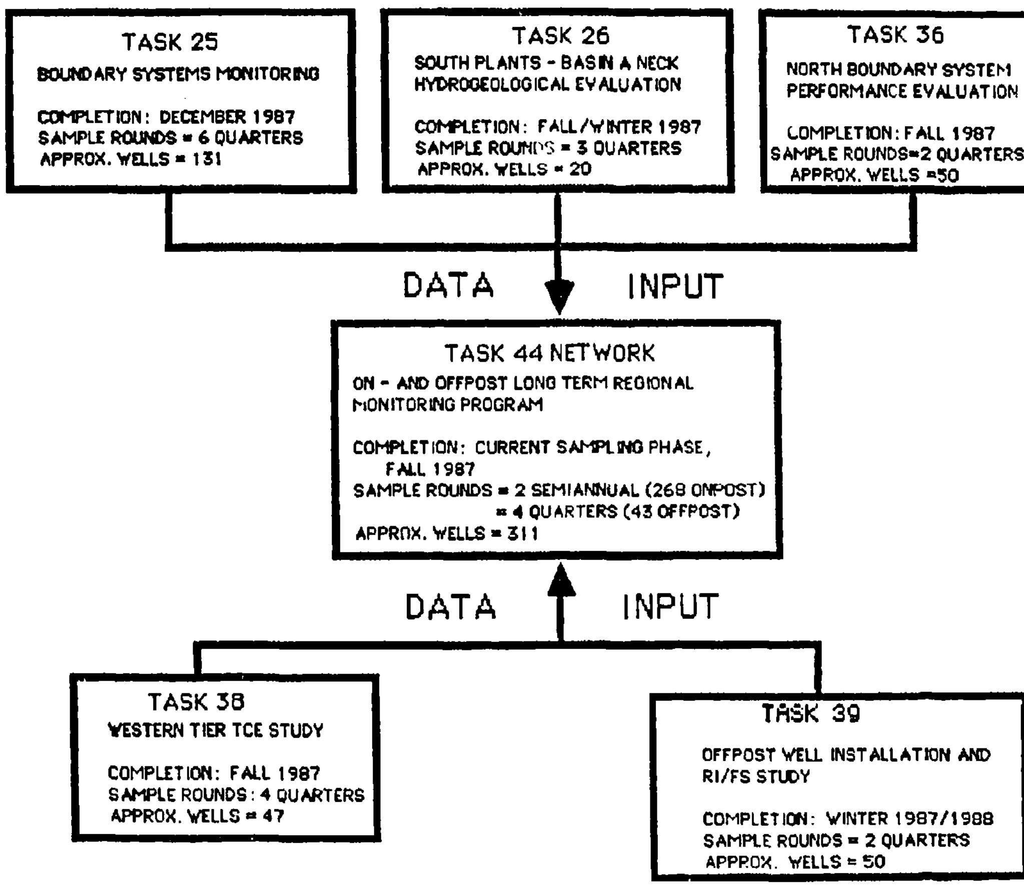

Figure 1.2-2
DETAILED GROUND WATER STUDIES AND THEIR RELATIONSHIP TO TASK 44

SOURCE: HLA, 1987

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- o Evaluate the existing monitoring program for data deficiencies and assess the need for additional wells; and
- o Integrate all data from water related tasks and supply appropriate information to Task 23 efforts including data bases, contaminant distribution maps, and hydrogeologic assessments.

Task 44 will establish the hydrologic core data base for and provide to the Endangerment Assessment (EA) and Feasibility Study (FS) groups adequate interpretation and characterization of hydrologic, geologic, and geochemical data so that their specified goals can be achieved.

The overall Task 44 program will be designed to be dynamic in nature and will be modified, as required, in response to ongoing data evaluation and/or changes in the SOW or task objectives. Task 44 will form the base or trunk hydrologic program, while other efforts (Tasks 25, 36, 38, 39, etc.) will be tributary or branch efforts which will satisfy specific individual task needs, as well as augment the Task 44 program.

In addition to 27 sq mi of onpost area covered by Task 44, 14 sq mi of the offpost area are being monitored as shown in Figure 1.2-3. The offpost area extends northwestward from RMA to the South Platte River. Several other detailed ground water tasks address localized areas within the Task 44 study area. The areas covered by each of these tasks are shown in Figure 1.2-3.

All studies under Task 44 will be performed in accordance with the requirements and technical specifications discussed in Section C-3 and Appendices A (USATHAMA, 1982, RIC#87048R03) and B (USATHAMA, 1983) of Contract DAAK-11-84-D-0016, except where modified as required for technical/litigation standardization. Standardized methods, protocols, and criteria will be consistent with those performed in Tasks 1, 2, and 4 and as established during subsequent meetings between the Army and contractors. Services conducted under Task 44 will include collection, analysis, reduction, compilation, and assessment of environmental data for both surface water and ground water. Ground water elevation and water quality

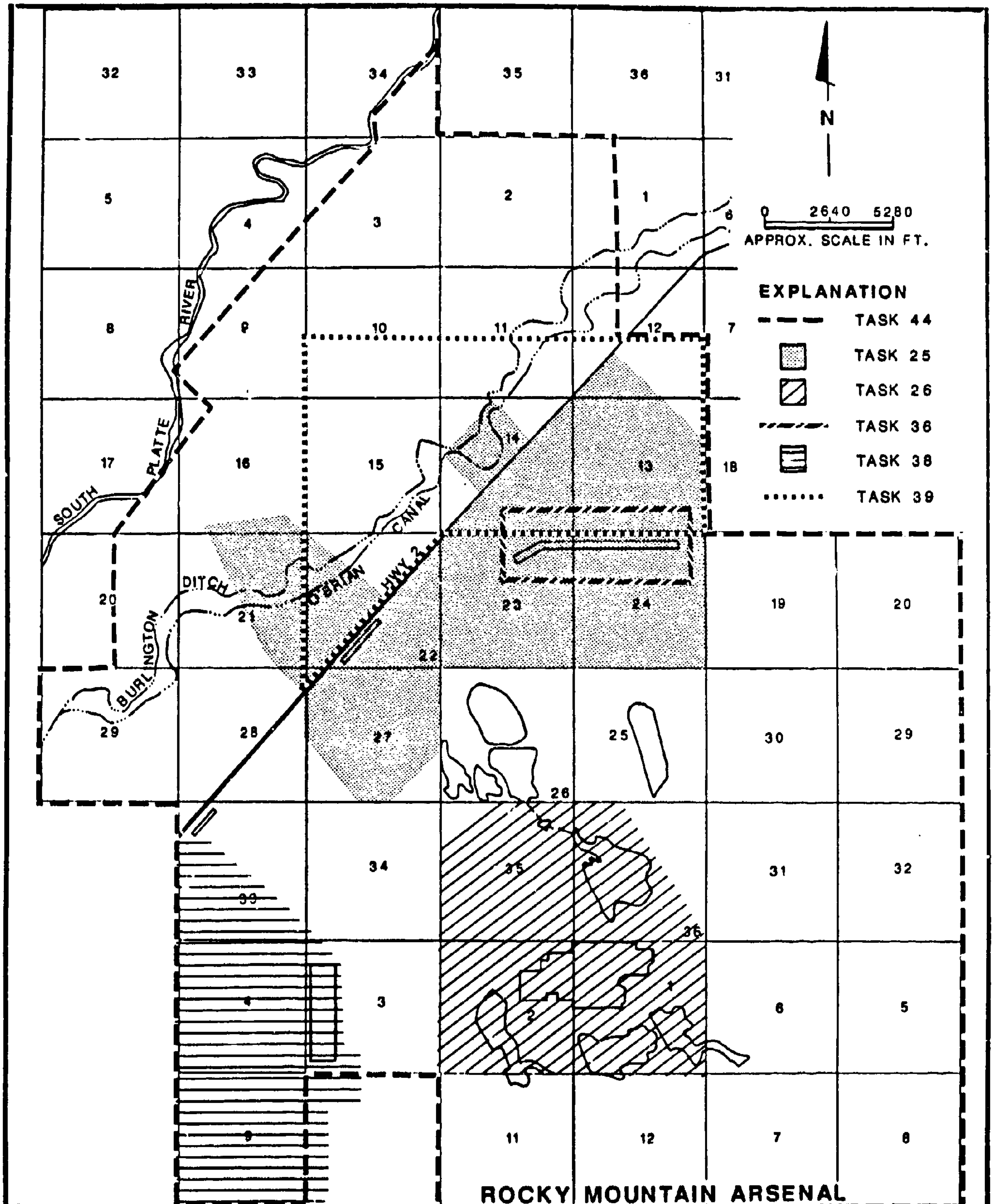

Figure 1.2-3
AREAL EXTENT OF TASK 44 AND OTHER RELATED GROUND WATER PROGRAMS

SOURCE: HLA, 1987

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data will be collected on a quarterly and/or semiannual basis. Stream flow evaluations and surface water event sampling will also be conducted.

1.3 GEOLOGY

The topography at RMA consists of rolling hills, expansive areas of plains, and small, shallow, enclosed basins. The maximum topographic relief is approximately 220 feet (ft). The elevation above mean sea level (msl) ranges from 5,340 ft at the south boundary to 5,120 ft at the northern boundary. The topographic surface at RMA slopes gently northwest toward the South Platte River at approximately 0.35 degrees (Figure 1.3-1).

RMA is located within the geologic province of a structural depression called the Denver Basin. The basin is an elongate, north-south trending feature, 300 mi long and 200 mi wide, covering north-central Colorado and parts of Wyoming and Nebraska. The basin is bound by mountains of the Front and Laramie Ranges on the west, the Hartville Uplift and Chadron Arch on the north, and the Las Animas Arch and Apishapa Uplift on the south. The basin is an asymetric syncline with a steeply dipping western flank that exposes several sedimentary units in outcrop along the Colorado Front Range. The eastern flank of the basin is gently dipping. Regional dip of bedrock at RMA is to the southeast at 0.5 degrees or less. The basin axis trends north-south and occurs closer to the western flank.

Prior to formation of the Denver Basin in its current structural configuration, the basin area was host to a series of orogenic, transgressive, and regressive events during the Cambrian to Late Cretaceous periods. Various sedimentary strata were deposited during this time and include conglomerate, sandstone, shale, and limestone units. The Denver Basin was downwarped to a syncline during the Late Cretaceous-early Tertiary Laramide orogeny, and the Denver Formation was deposited during this general time period. Continued sedimentation occurred in the basin throughout the Tertiary period. Tertiary-Quaternary faulting and regional uplift eroded

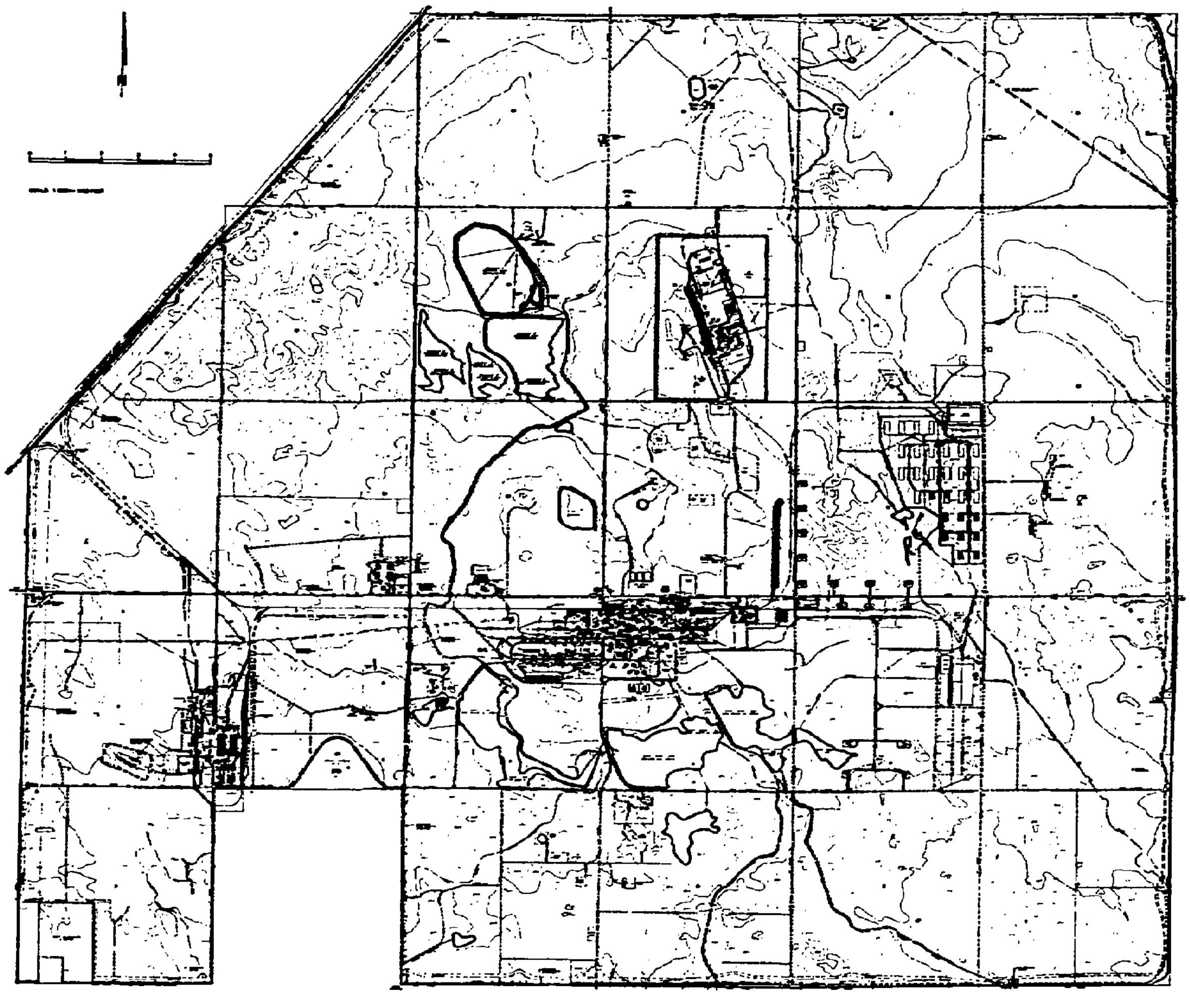

Figure 1.3-1
TOPOGRAPHIC MAP OF RMA
(CONTOUR INTERVAL - 10 FEET)

SOURCE: USGS, 1979

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over 1,000 ft of sediments and carved deep paleochannels into the surface of the Denver Formation in the RMA area. Figure 1.3-2 shows paleochannels and paleotopographic relief as determined by most recent ESE efforts. Deposition of alluvium on this erosional surface occurred during the Quaternary period.

Sediments present at the land surface at RMA consist of unconsolidated alluvial and eolian deposits of Quaternary age (Figure 1.3-3). The material is composed primarily of alluvial fill, dune sand, and glacial outwash containing cobbles, boulders, and minor beds of volcanic ash in a more predominant matrix of sands, gravels, silts, and clays. The combined thickness of the surficial materials ranges from 0 to 130 ft. Thicker deposits may infill paleochannels eroded into the surface of the Denver Formation (Figure 1.3-2), as indicated by lithologic logs from boreholes within channel areas. Locally, deposits may be cemented by calcium carbonate forming conglomerates, sandstones, etc. The alluvial material commonly becomes more coarse at the base near the bedrock contact.

The Denver Formation underlying RMA consists of 250 to 400 ft of olive, bluish-gray, green-gray, and brown bentonitic claystone and siltstone. It is interbedded with poor to moderate sorted, weakly lithified, tan to brown, fine- to medium-grained sandstone. The contact between the alluvium and Denver Formation is often marked by a weathered zone in the Denver that may be up to 40 ft thick. Lignite beds and carbonaceous shales are common, as are volcanic fragments and tuffaceous materials. Sandstones are mainly discontinuous to semicontinuous lenticular bodies which may also possess a shoestring or alluvial channel morphology. These lenses are distributed in thick claystone sequences and are poorly defined because the sandstones often grade into the encompassing clay and shale. A shale claystone layer ranging from 75 to 200 ft thick marks the Denver-Arapahoe contact in the RMA area. Several regional RMA geologic assessments indicate that the geology and hydrology of RMA is quite complex (Ertec, 1982, RIC#83013R01; May, 1982, RIC#82295R01).

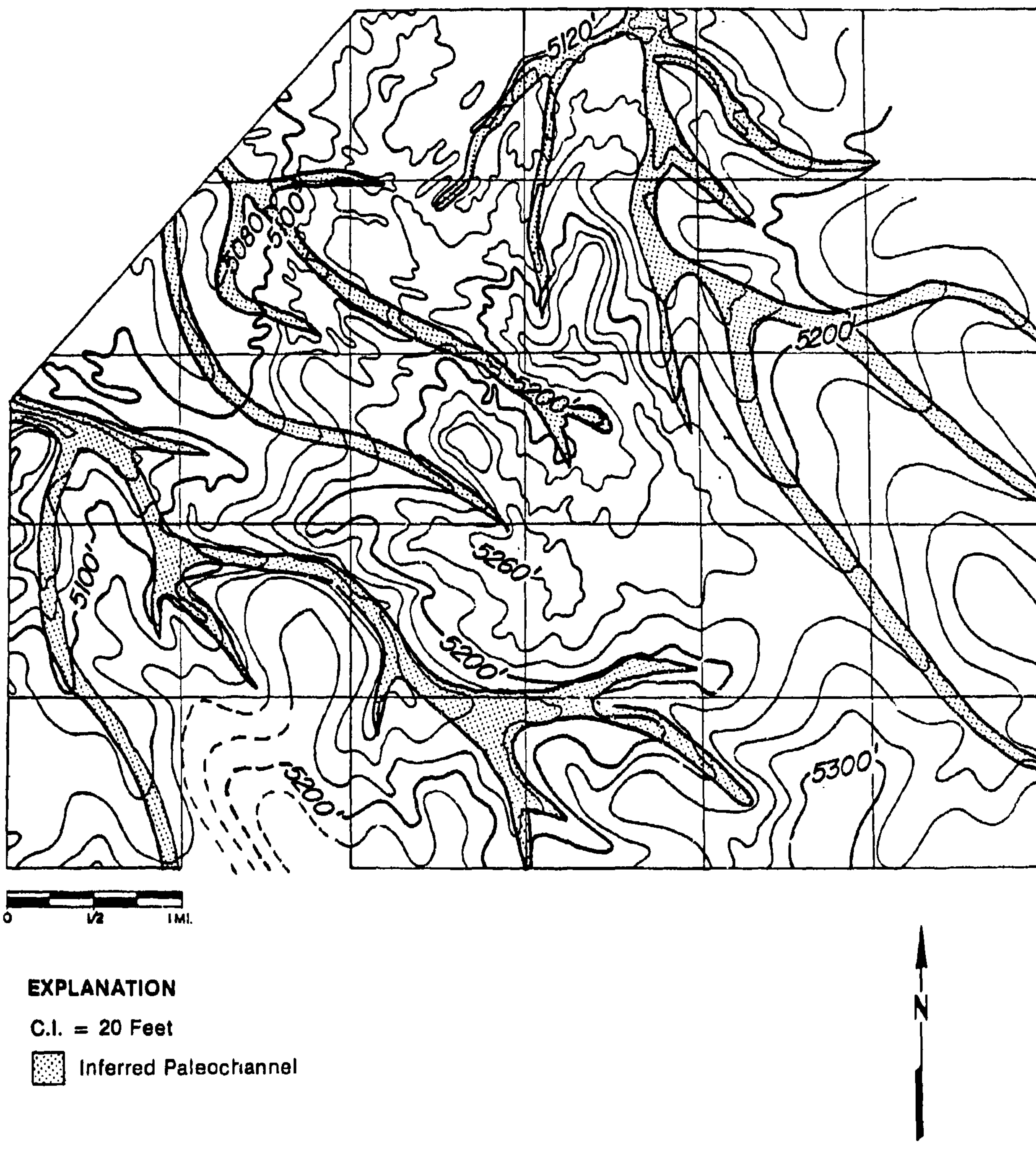

Figure 1.3-2
BEDROCK ELEVATION AND INFERRED PALEOCHANNEL LOCATION
SOURCE: ESE, 1987

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RMA TASK 4 4/86

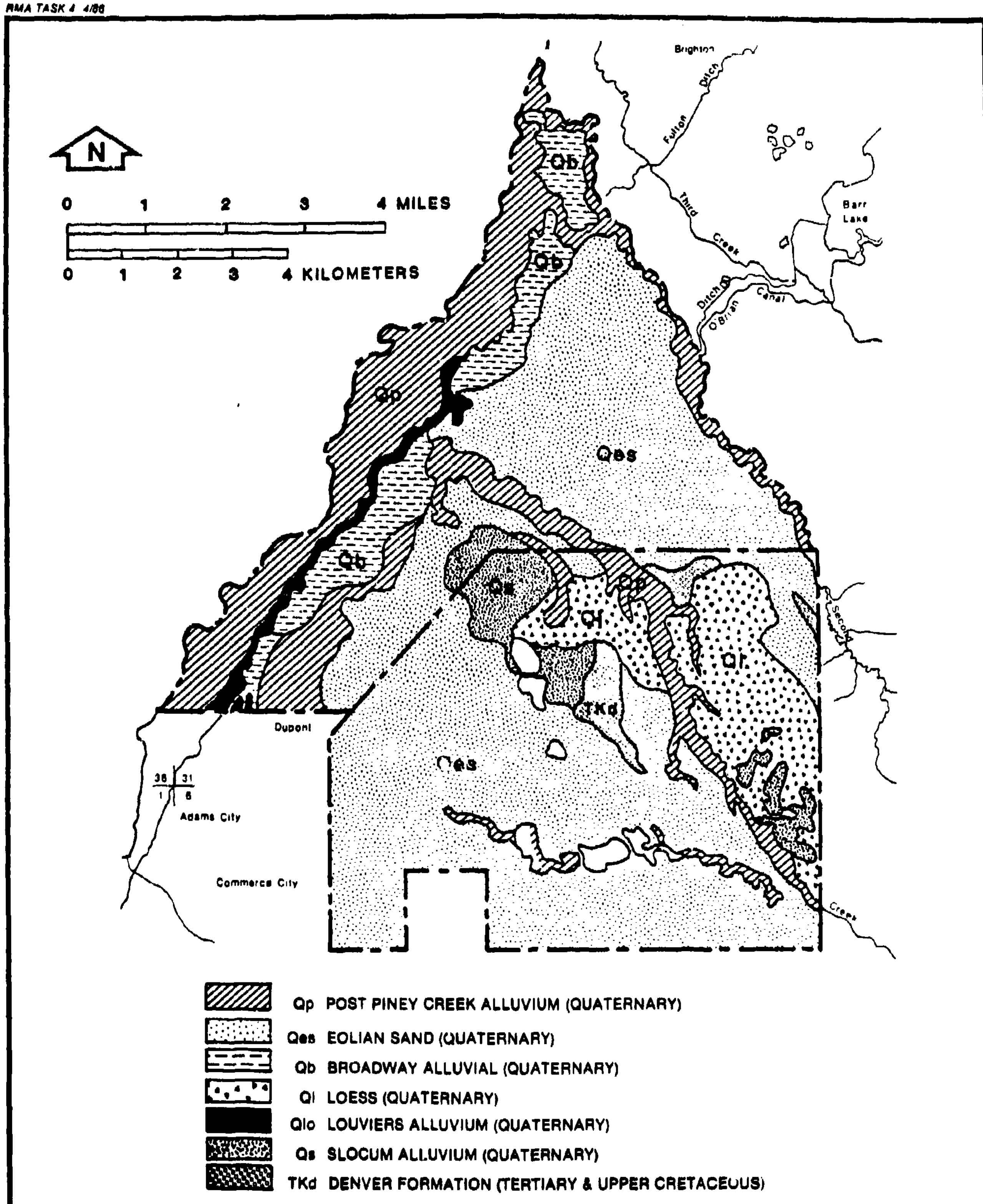

Figure 1.3-3
GEOLOGIC MAP OF RMA AREA

SOURCE: USGS, 1981

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1.4 GROUND WATER HYDROLOGY

The Denver ground water basin contains significant economically important ground water resources. The ground water basin underlies the area extending from Greeley, Colorado in the north to Colorado Springs, Colorado in the south and from the Front Range Uplift in the west to near Limon, Colorado in the east. Formations ranging in age from Pennsylvanian to Tertiary contain water-bearing units. Surficial alluvial deposits and Front Range crystalline rocks may locally yield enough water to be considered aquifers.

The Late Cretaceous Fox Hills Sandstone, the Late Cretaceous Laramie Formation, the Late Cretaceous-early Tertiary Denver and Arapahoe Formations, and the early Tertiary Dawson Arkose are the four major bedrock aquifers in the Denver Basin (Romero, 1976, RIC#81266R69). The stratigraphic relationship of these formations are shown in generalized geologic cross sections drawn from west to east and from south to north through the basin (Figure 1.4-1). The Late Cretaceous Pierre Shale underlies the Fox Hills Sandstone and is considered the base of the major bedrock-aquifer system because of its great thickness and its minimal permeability (Robson and Romero, 1981, RIC#82350M02).

Two major hydrogeologic subdivisions of the Denver ground water basin are of primary concern at RMA. The Denver Formation and the unconsolidated Quaternary alluvial and eolian surficial deposits contain aquifers that comprise the shallow ground water regime under RMA. Deeper aquifers such as the Arapahoe and Laramie-Fox Hills are below the zone of ground water contamination and are not considered in this study.

The entire sequence of surficial alluvial materials is considered capable of bearing water. The saturated thickness of the alluvium varies from 0 to over 60 ft at RMA, with thickest occurrences in the west and southwest areas of RMA infilling paleochannels. Approximately 20 to 25 percent of the alluvium underlying RMA is unsaturated (Figure 1.4-2). Overall alluvial permeability is enhanced by the occasional coarse nature of materials, particularly at the base of the alluvium where gravels, cobbles, and boulders may infill paleochannels incised into the Denver Formation. These paleochannels (infill) may provide dominant ground water flow paths; however, it is anticipated that paleochannels may exhibit less control on

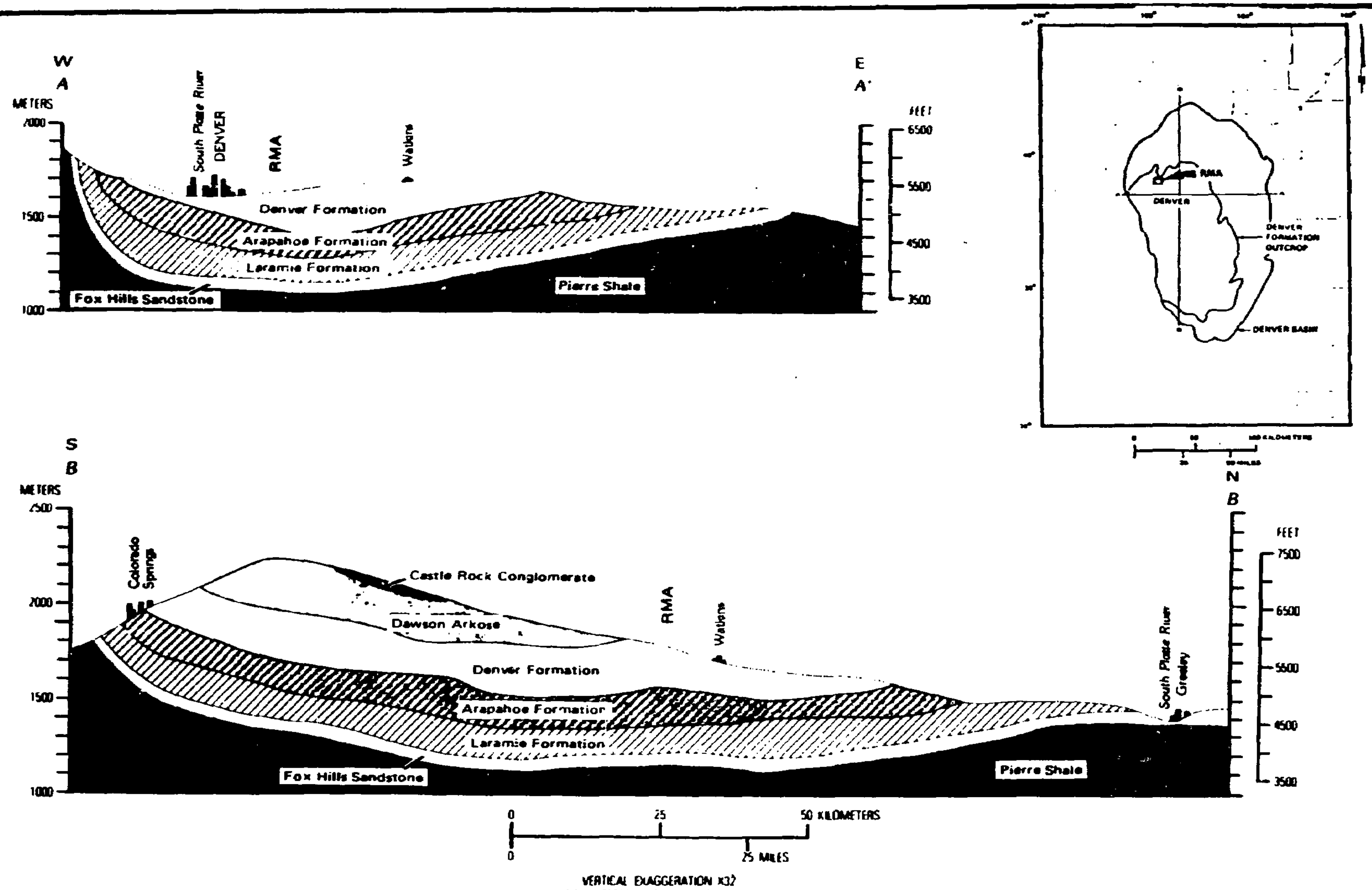

Figure 1.4-1
UPPER STRATIGRAPHIC SECTIONS OF DENVER BASIN

SOURCE: ROBSON, 1981

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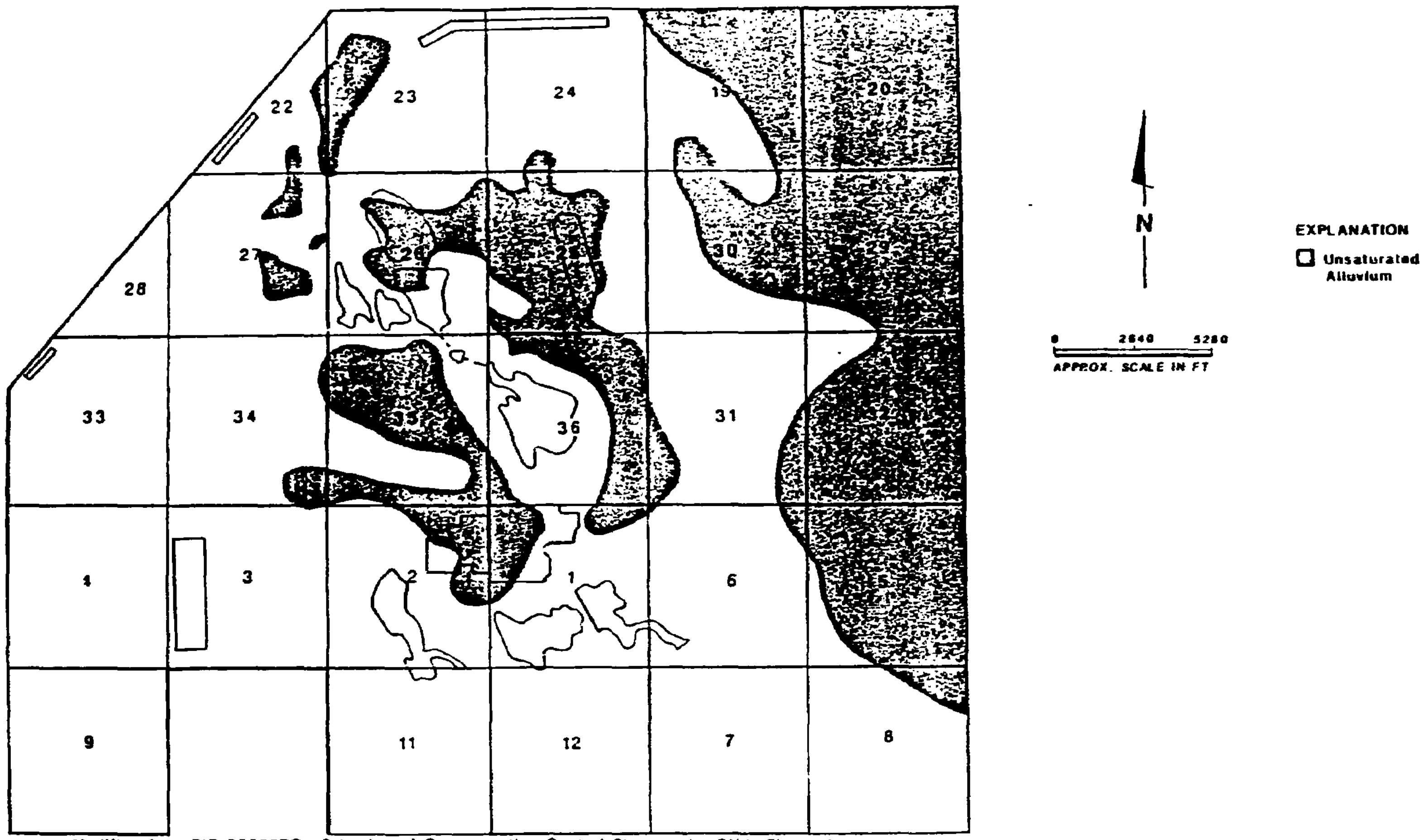

Modified from RIC 83326R01-Selection of Contamination Control Strategy for RMA, Figure 3.

Figure 1.4-2
APPROXIMATE AREAL EXTENT OF UNSATURATED ALLUVIUM

SOURCE: HLA, 1987

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ground water flow and contaminant transport in areas of thick, saturated allivium. The alluvial aquifer is generally unconfined and under water table conditions, though local clay lenses may produce perched or confined conditions.

As determined from pumping tests, the hydraulic conductivity of the alluvial aquifer ranges from approximately 1.0 to 1.0 x 10^{-3} centimeters per second (cm/sec) (May, 1982, RIC#82295R01). Higher hydraulic conductivity values are associated with buried channels. The transmissivity ranges from 2.16 to 360 cm^2/sec, and the storage coefficient ranges from 0.1 to more than 0.4 (RMACCPMT, 1983, RIC#83326R01).

The Denver aquifer is composed primarily of lenses of weakly cemented to compacted, fine- to medium-grained sandstones. These lenticular sandstones grade laterally and vertically into relatively impermeable silts and claystones. Primary ground water transport takes place in the lenses and paleochannels where flow occurs in the void spaces between coarser materials. These individual sandstone units may form separate, distinct, water-bearing zones. The Denver sands are often laminated, so horizontal flow would tend to be much greater than vertical flow (May, 1982, RIC#82295R01).

As determined from slug and laboratory tests, the hydraulic conductivity of the Denver sands (tested horizontally) is approximately 10^{-3} to 10^{-4} cm/sec compared to 10^{-7} cm/sec for the claystones (May, 1982, RIC#82295R01).

The RMA ground water flow paths of the two primary aquifers (alluvial and Denver) are complicated by the following factors:

- o Contrasts in permeability between the buried channels and adjacent less permeable alluvium;
- o Contrasts in permeability among and between the Denver sandstones, adjacent claystones, and overlying alluvial materials; and
- o The geometry of the recharge and discharge areas.

Flow within the alluvial aquifer generally occurs in a north to northwesterly direction (Figure 1.4-3). Deviations from the general patterns presented in Figure 1.4-3 may occur as a result of permeability changes controlled by alluvial sedimentological conditions. Deviations are also caused by recharge in some areas such as the South Plants, where a large ground water mound has been mapped.

The primary source of recharge to the alluvium is from surface water and the infiltration of precipitation, that occurs either onpost or upgradient of RMA. Ground water in the alluvial aquifer flows offsite to the north and northwest and eventually discharges to the South Platte River.

Ground water flow within the Denver Formation also occurs in a generally north to northwesterly direction. The confining effect of the claystones and upgradient offpost recharge of the Denver aquifer produces artesian conditions in much of the Denver aquifer underlying RMA. Recharge to the Denver Formation occurs as a result of downward flow from the overlying Dawson Arkose aquifer south of RMA, precipitation percolation on the Denver Formation outcrops along the western margin of the Denver basin, and downward flow from the overlying alluvial aquifer (Ertec, 1982, RIC#83013R01).

The relative complexity of the ground water regime in the area is due to intricate geologic, stratigraphic, and topographic relationships between and within the Denver Formation and the overlying surficial deposits. The alluvial and Denver aquifers are locally isolated from each other by semipermeable confining layers that restrict flow between the more permeable strata. Flow between the more permeable strata occurs where confining beds are absent, creating interconnections between aquifers. Water level measurements from Task 4 well clusters suggest the Denver Formation contains several distinct and laterally discontinuous water-bearing zones.

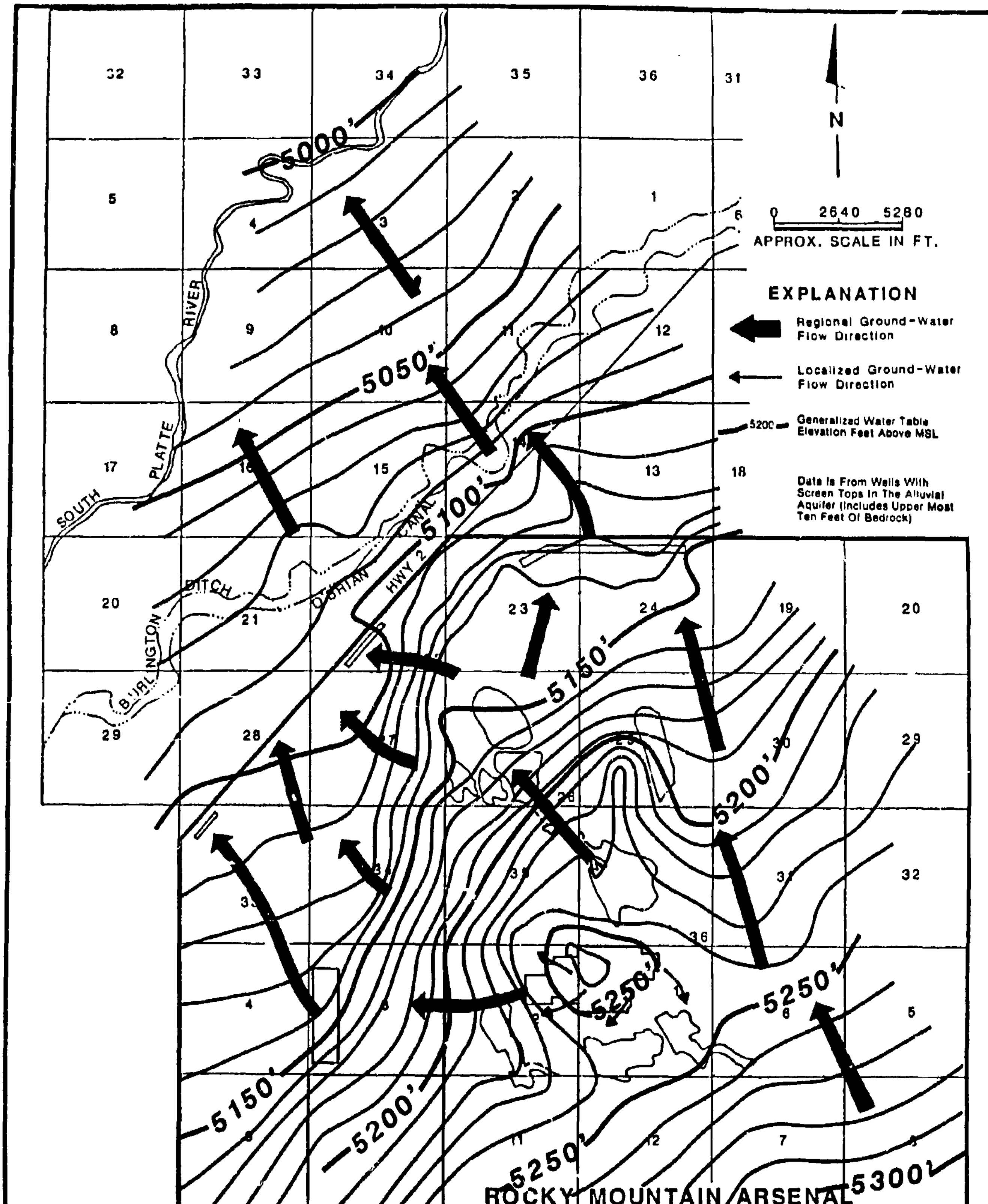

Figure 1.4-3
GENERALIZED ALLUVIAL WATER TABLE AND DOMINANT ALLUVIAL GROUND WATER FLOW DIRECTIONS
SOURCE: ESE, 1987

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1.5 SURFACE WATER HYDROLOGY

The surface water hydrology (Figure 1.5-1) at RMA is dominated by two major drainage basins, Irondale Gulch and First Creek. Portions of larger drainage basins or smaller, less significant basins account for the remaining drainage on RMA and include the Sand Creek drainage, Sand Creek Lateral drainage, Northwest drainage, Basin F, Basin A, and Second Creek Basin.

First Creek occupies a well-defined channel that crosses the east and north boundaries of RMA. Flow within First Creek is intermittent, occurring during the Spring season and major storm events. Several tributaries contribute flow to First Creek on RMA. Flow components include surface water runoff, effluent from the Sewage Treatment Plant, and overflow drainage from the North Bog.

Irondale Gulch is characterized by poorly defined channelization, which has produced many small basins that are connected only during major flood events. The Irondale Gulch drainage area is much smaller than that of First Creek and has been modified by construction of subdivisions, the Lower Lakes, man-made channels, and storm drains. Four major flow routes which occur in this drainage basin are the Highline Lateral, Uvalda Interceptor, Havana Interceptor, and the Lower Lakes.

The Highline Lateral is a man-made channel that delivers water to RMA from the Highline Canal. Planned diversions from the Highline Canal are controlled by man-made structures. Water in the Lateral flows into Lower or Upper Derby Lake.

The Uvalda Interceptor collects storm runoff from the residential area south of RMA and transports it to Lower or Upper Derby Lake. This is a well-defined, unlined channel that has been breached during major flood events.

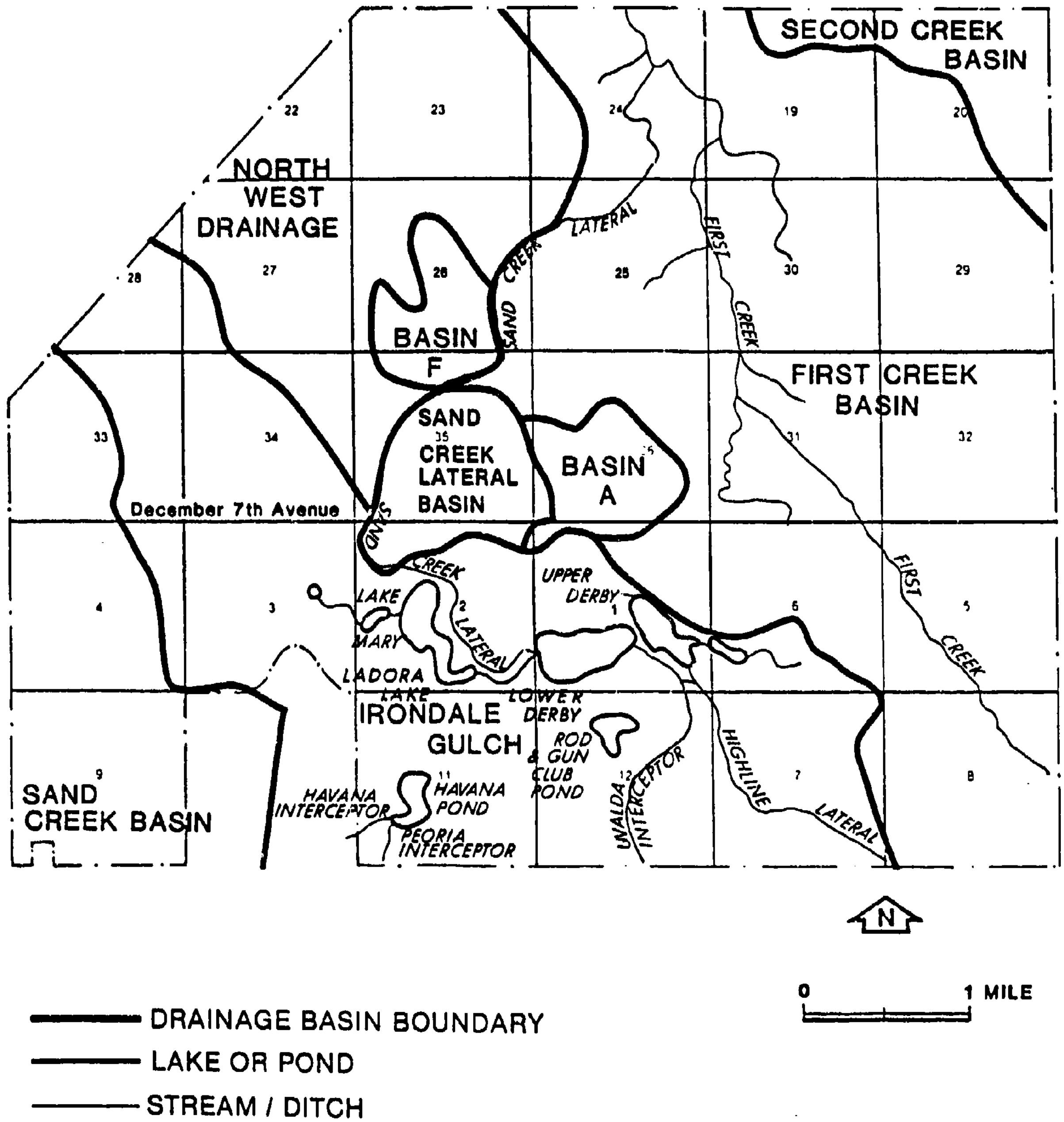

Figure 1.5-1
RMA SURFACE WATER FEATURES

SOURCE: RCI, 1981

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The Havana Interceptor flow consists of storm and nuisance flows from Stapleton, a large industrial complex, and portions of the Montbello residential area. A large surface impoundment, the Havana Pond, collects water from the Havana Interceptor, thereby providing ground water recharge. Water from the pond can also be released through an unlined ditch running northeast to the Sand Creek Lateral.

The final major flow route within the Irondale Gulch drainage is the Lower Lakes. The Lower Lakes consist of four man-made lakes and one pond. Upper Derby Lake serves as an overflow catchment in case of flood, while Lower Derby Lake receives the local storm runoff and is in direct contact with the water table. Lake Ladora serves as a cooling water source for the RMA power station and is also in direct contact with the water table. Ladora, Upper Derby, and Lower Derby Lakes are both recharge and discharge areas. During periods of high flow (March through August), ground water is replenished from these lakes. During periods of low surface flow (September through February), ground water is released to these lakes. Lake Mary, located west of Ladora Lake, is not in contact with the water table and is, therefore, primarily a recharge area. The Rod and Gun Club Pond was created during a major flood and acts as a recharge basin. This pond is usually dry except during major flood events when it receives overflow from the Uvalda Interceptor and Lower Derby Lake.

In addition to the First Creek and Irondale Gulch drainage basins, many minor flow paths exist on RMA (Figure 1.5-1). Sand Creek drainage occupies the southwest corner of RMA and is adjacent to Irondale Gulch. The drainage exhibits a lack of channelization, and any flow occurring during periods of extreme rainfall would be local and drain overland short distances to one of the many natural depressions found in the basin.

The Northwest drainage lies in the northwest corner of RMA. It is bounded by Irondale Gulch on the southwest, Sand Creek Lateral drainage and Basin F drainage on the south, and First Creek Basin on the east. Like the Sand Creek drainage, the Northwest drainage is virtually void of major

channelized flow and has a large number of natural depressions. Surface water flows to the northwest, and the flow is localized and occurs only after extreme rainfall events.

The southern portion of Basin A collects runoff from a large portion of the South Plants area. Runoff from the South Plants area may be transported to Basin A waste seepage/evaporative pond via the contaminated waste lines or through culverts under December 7th Avenue. The natural depression was modified by adding embankments to provide greater storage when the area was being used for waste containment. Because Basin A no longer receives contributions from waste streams, its storage capacity is sufficient to contain much of the incident local precipitation. Surface water overflow from Basin A is possible during major runoff events and rapid snowmelt.

Sand Creek Lateral drainage is also located near the center of RMA and occurs to the west of the Basin A drainage. The Sand Creek Lateral drainage is slightly larger than Basin A drainage and has one major channel, the Sand Creek Lateral. This channel forms the north and west boundaries of the drainage and intercepts flow from the drainage area. Flow is to the northwest and occurs only after large precipitation events. Near the north end of the drainage, Sand Creek Lateral is blocked immediately downstream of a diversion structure that delivers water to the southern portion of the Basin F drainage. A secondary channel in the Sand Creek Lateral drainage originates near the lime settling ponds in Basin A. This secondary channel flows under Sand Creek Lateral at the point where the two cross and then flows into the Northwest drainage. The Sand Creek Lateral drainage basin contains Basin B, a dry reservoir near the eastern edge of Section 35. The basin may have been used as a caustic waste storage basin that was filled from a pipeline from the South Plants area. This basin has no definite outlet and is normally dry.

The Basin F drainage occurs just north of the Sand Creek Lateral drainage and is bounded on the east by the First Creek Basin and on the west by the

Northwest drainage. The Basin F drainage area includes Basins C, D, E, and F. It is currently assumed that all local flow generated in the Basin F drainage as a result of precipitation events will flow to the nearest depression (i.e., Basins C, D, E, and F). A ditch connects Basins B and C and is the only other source of inflow into the basins other than precipitation. This ditch discharges into a culvert under the Sand Creek Lateral. Inflows to Basin B are in the form of two ditches originating from Basin A. As mentioned earlier, it is doubtful that any flow will enter the Basin F drainage system via these ditches.

1.6 CONTAMINANT SITES

The primary sites that may be contributing to ground water contamination at RMA are the South Plants area, the waste storage basins (Basins A, B, C, D, E, and F), the chemical sewer system, and locations within the rail classification yard (Figure 1.2-2). These sites are discussed below.

1.6.1 SOUTH PLANTS

Operations at the South Plants area began in 1942 with the manufacture of chemical munitions, followed by (later) production of pesticides and herbicides. Chemical wastes were discharged into the lime settling ponds north of the South Plants area and south of Basin A (Figure 1.2-2). Numerous uncontrolled discharges of contaminants also occurred in this area, including a major benzene spill in 1948, pesticide spills, leakage of contaminants from the area sewer system, and infiltration of wastes from building basements and sumps.

1.6.2 BASIN A

Basin A received waste and byproducts from most of the industrial processes conducted at RMA. The basin was the primary receptor of liquid waste until 1956. Aerial photographs indicate that fluids were present in the basin through 1958. Photographs also indicate that the basin was used for trench disposal of wastes from 1958 to 1975 (RMACCPMT, 1984, RIC#84034R01).

1.6.3 BASIN F

Basin F was constructed in 1956 in response to the need for expanded waste storage. The 93-acre basin was constructed with an asphalt-lined bottom protected with a 12-inch-thick layer of sand to restrict contaminant migration. Numerous processes have affected the containment performance of the Basin F system, and these include:

- o Wave action along the shoreline;
- o Rips or cracks in the asphalt liner;
- o Cyclic exposure of the liner to liquid wastes, sunlight, and weather conditions; and
- o Incompatibility of some of the wastes and the asphalt liner.

These problems have resulted in waste discharges to the underlying ground water system.

1.6.4 BASINS C, D, AND E

Basin C is an unlined evaporation pond that received discharge from the North (GB) Plant, but also held large volumes of fresh water from the Sand Creek Lateral. In addition, approximately 100 million gallons of liquid wastes were pumped into Basin C from Basin F during repair of the Basin F liner in 1957. Basins D and E are also unlined and were used to hold overflow from Basin A prior to construction of Basin F.

Potential ground water contaminant sources upgradient of these basins may mask ground water contaminant contribution from Basins C, D, and E. All basins have contained similar chemical compounds derived from the South Plants and GB Plant manufacturing areas.

1.6.5 CHEMICAL SEWER SYSTEM

Contaminants may be introduced to the ground water system via the RMA chemical sewer system. Several sections of the system are below the water table, and numerous breaks and leaks reportedly occurred when the lines were still used for contaminant transport (Stollar and van der Leeden, 1981, RIC#81293R05). Major leaks from the sewers may have occurred in Basin A,

Basin A "neck", the South Plants area, and Basin F areas. Even after contaminant transport was discontinued, the sewer system may still have also contributed to overall ground water contamination by acting as a conduit for contaminated water.

1.6.6 RAIL CLASSIFICATION YARD

The rail classification yard was identified as a potential site of solvent and pesticide contamination in 1980 when these contaminants were detected in the water supply wells for the Irondale community. The pesticide contamination resulted from a suspected DBCP spill within the rail classification yard. Ground water contamination from this suspected spill is currently being mitigated by the Irondale Containment System (ICS). Other smaller spills may have occurred in this area, but are not considered significant. These smaller spills may have occurred in the railyard and surrounding area, while other potential sites may occur offpost to the south and west. This area is being investigated under Task 38.

1.7 WATER QUALITY MONITORING PROGRAMS

1.7.1 GROUND WATER QUALITY

A significant effort has been devoted to monitoring RMA ground water quality over the last 10 years. Ground water quality monitoring efforts have included both regional and site-specific investigations. Prior to 1985, regional monitoring was conducted under the RMA 360° Monitoring Program and site-specific investigations were conducted in and around the Boundary Containment Systems. Since 1985, regional monitoring programs have included Tasks 4 and 44, and site-specific investigations have included Tasks 25, 26, 36, 38, and 39.

Approximately 2,000 wells have been installed at RMA over the past 30 years: however, the majority of these wells have not been sampled on a routine basis. Many of the wells that were not sampled routinely have been found to be dry, destroyed, or obstructed, or poorly documented with respect to construction and completion.

Ground water quality data has been compiled in the USATHAMA data base and utilized to generate contaminant contour maps for the shallow ground water system. The data used to construct these maps are primarily from alluvial wells.

Figure 1.7-1 depicts generalized distribution of alluvial ground water contamination. The figure also illustrates the extent of composite contamination related to organochlorine compounds, DIMP, volatile halocarbons, and DBCP. Contaminant distribution patterns presented in Figure 1.7-1 reflect ground water flow (Figure 1.4-3). The general northwesterly trend of ground water flow is split into northern and northwestern components, and may be affected by the bedrock (Denver Formation) high in the western portion of Section 23 on RMA (Figure 1.3-2). Ground water contaminants originating from the South Plants Area and Basin A may travel to the north or northwestern boundaries, and contaminants from Basin F are primarily migrating toward the RMA north boundary.

Several ground water monitoring programs have been conducted and remain in operation at RMA to accomplish a variety of objectives. These include regional programs such as the 360° Monitoring Program, and successor programs such as Task 4 and Task 44. Other programs addressing site specific problems have included the Basin F Monitoring Program, the North Boundary Containment System (NBCS) Program, the Northwest Boundary Containment System (NWBCS) Program, and the ICS Program performed by SCC. The NWBCS and NBCS are now being monitored jointly under Task 25 (Figure 1.2-3). The Basin F Monitoring Program has been included within the scope of Task 44. A brief summary of the historical ground water monitoring programs is presented below.

1.7.1.1 <u>360° Ground Water Monitoring Program</u>

The Cease and Desist Order (1975) issued by the State of Colorado required a regional surveillance program that monitors both ground water and surface water hydrology and water quality. This monitoring program, referred to as the 360° Monitoring Program, was initiated in 1975. Objectives of the program are to satisfy the requirements of the Cease and Desist Order and to provide a basic program for RMA surveillance.

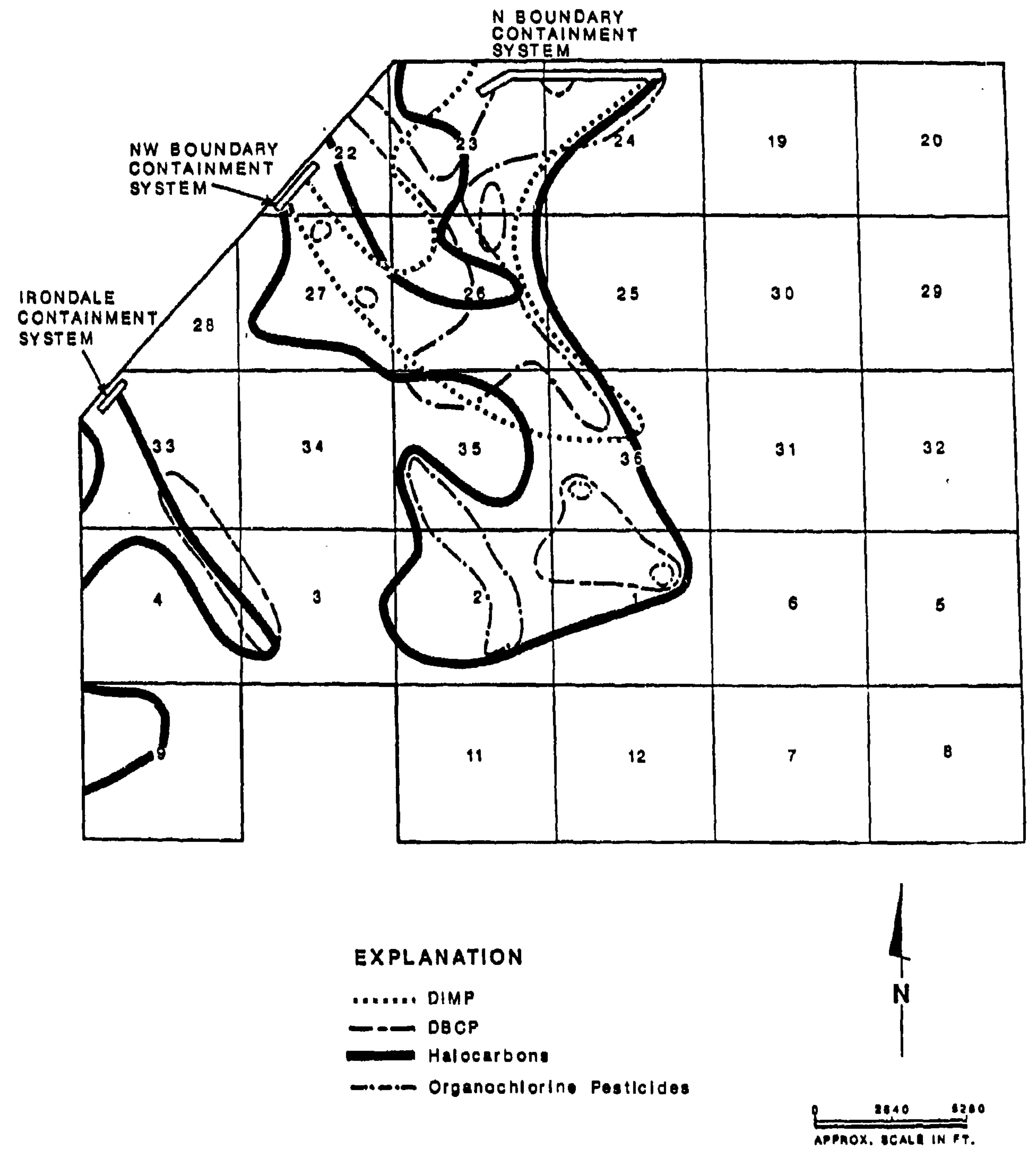


Figure 1.7-1
GENERALIZED DISTRIBUTION PATTERNS FOR MAJOR CONTAMINANT GROUPS IN THE ALLUVIAL GROUND WATER SYSTEM. (FROM ISP, TASK 4).

SOURCE: HLA, 1987

Prepared for:
U.S. Army Program Manager's Office For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

The Initial 360° Monitoring Program consisted of 153 wells and surface water sites. The program has been modified periodically since 1975, as the number and specific location of wells sampled has since been altered because selected wells have been abandoned and new ground water monitoring wells have been installed. In 1976, the 360° Monitoring Program (Revision II) collected samples from approximately 55 ground water wells, including many wells located north and northwest of the RMA boundary. Twelve surface water samples were collected and analyzed in the 1976 sampling effort. Water samples from monitoring wells were analyzed on a quarterly basis for DIMP, DCPD, DBCP, chloride (Cl), fluoride (F), magnesium (Mg), calcium (Ca), potassium (K), sodium (Na), nitrate, sulfate, alkalinity, specific conductivity, and pH.

In 1985, Revision III of the 360° Program was implemented and consisted of 43 offpost wells and 9 surface water sampling sites. The 360° Program also collected water level data from 490 monitoring wells on a quarterly basis in 1985. The onpost portion of the 360° Program was replaced by the Task 4 Monitoring Program. Task 44 has incorporated the 43 offpost wells from the Revision III - 360° Program and many of the Task 4 wells.

1.7.1.2 Boundary Containment Monitoring Programs

As a result of offpost contaminant detection, three boundary containment systems were installed and are currently operating at RMA to control offpost discharge of ground water pollutants. These systems include the NWBCS, the NBCS, and the ICS. Ground water monitoring programs were developed to evaluate both the hydraulic and hydrochemical performance of the three boundary systems.

North Boundary Containment System

The NBCS has been in operation for several years and includes a physical barrier (slurry wall), ground water extraction wells, and recharge wells. Extraction wells are located upgradient of the slurry wall to intercept contaminated ground water. Extracted ground water is treated by carbon

adsorption and the treated water is recharged to the alluvium via ground water recharge wells and a recharge lagoon on the downgradient side of the slurry wall.

Historically, the NBCS Monitoring Program includes sampling of 80 onpost and offpost wells in the alluvial and Denver aquifers. Samples from these wells were collected on a quarterly basis, but were collected more frequently if problems with the system arose or if operational parameters were changed. All water samples collected from the monitoring network were analyzed for DIMP, DCPD, DBCP, endrin, dieldrin, isodrin, aldrin, oxathiane, dithiane, p-chlorophenylmethyl sulfide (CPMS), p-chlorophenylmethyl sulfoxide (CPMSO), p-chlorophenylmethyl sulfone ($CPMSO_2$), chloride, and fluoride. Monitoring of the treatment plant at the NBCS is currently incorporated within Tasks 25 and 36.

Northwest Boundary Containment System

The NWBCS has been in operation for approximately 3 years. This containment system consists of both a physical barrier (slurry wall) for a portion of the length of the system and a hydrologic barrier. Ground water extraction wells collect contaminated ground water that is treated by carbon adsorption prior to recharge downgradient of the slurry wall.

This system has historically been monitored by 45 onpost and offpost monitoring wells sampled on at least a quarterly basis. Water samples collected from these wells were analyzed for DIMP, DBCP, endrin, dieldrin, isodrin, aldrin, chloride, and fluoride. The NWBCS monitoring program is currently incorporated within Task 25 efforts.

Irondale Boundary Containment System

The ICS was constructed in 1981 and is operated by SCC, which supervises collection and analysis of the water samples associated with operation of the system. This hydrologic control system is located at the southwest corner of the northwest RMA boundary (Figure 1.2-2) and consists of two rows of ground water dewatering wells and a single row of recharge wells downgradient of the extraction wells. Ground water beneath the ICS is extracted, treated, and recharged.

In addition to the above programs, a number of other ground water related programs have been conducted in the past. These programs include the North Boundary study, Pilot Containment System, Northwest Quadrant, and Nemagon Sampling Programs, which were all precursors to the various boundary containment monitoring programs. The Basin A Neck program was also conducted to examine the feasibility of installing a barrier system in this area. In addition, several discrete investigations of the ground water quality at RMA were conducted during a short period of time. These programs were conducted by U.S. Army Waterways Experimental Station (WES) or SCC. Other water quality investigations were conducted by the RMA Environmental Division (RMA-ED) under the Basin F Study, Regional Sampling, or Source Identification Programs.

These ancillary programs are not currently in operation. Since these programs are not necessary under regulatory requirements, they will not be incorporated into the Task 44 sampling effort. Information generated by these previous programs will be utilized for the well selection procedures discussed in Section 3.0 of this Technical Plan.

1.7.2 SURFACE WATER QUALITY

Limited information is available on surface water contamination at RMA. Preliminary analysis of water within First Creek indicated the presence of diethyl and dibutyl phthalates and cyclohexanone (RMACCPMT, 1983, RIC#83326R01). Chloroform, dieldrin, DBCP, and DIMP have also been detected (USATHAMA Edgewood Scientific Computer Center data base) in the First Creek samples. When flowing, the water in First Creek displays a slight but constant loss of volume towards the north. There appears to be interaction between water in First Creek and ground water, with ground water discharging to the creek south of RMA and First Creek surface water recharging ground water near the north RMA boundary.

The offpost storm drainages (Highline Lateral, Uvalda and Havana Interceptors) are considered free of RMA related contaminants (RMACCPMT, 1983, RIC#83326R01) within the Irondale Gulch drainage basin, although DBCP

and DIMP have been detected in these areas in the past (USATHAMA Edgewood Scientific Computer Center data base). Two of the Lower Lakes have been sampled regularly for the past 5 years. Water from the lakes is free of detectable contamination, but dieldrin and mercury are present in lake sediments.

The Basin A ditch, a minor flow route conveying storm runoff from the South Plants area to Basin A, contains significant amounts of several contaminants including: chloroform, trichloroethylene, tetrachloroethylene, toluene, xylene, ketones, and benzene. These compounds are probably derived from past spills on surface soils (RMACCPMT, 1983, RIC#83326R01).

1.7.2.1 360° Monitoring Program

Surface water monitoring at RMA has been performed as part of the 360° Monitoring Program. Water samples were collected from 30 onpost and 4 offpost sites on a quarterly basis. Samples were analyzed for DIMP, DCPD, DBCP, Cl, F, Ca, K, Mg, Na, nitrate, sulfate, hardness, alkalinity, conductivity, and pH. Sampling points included various surface water features such as streams, ditches, lakes, and ponds.

In addition to collection of water quality data, an integral part of the 360° Program included collection and compilation of water quantity data. Flow and water level data were collected onpost weekly at 11 gaging stations and 3 lake sites. Additional measurements were recorded at two flow meters. Information was presented in monthly RMA Surface Water Balance Summaries.

1.8 SUMMARY OF TECHNICAL APPROACH

The purpose of this task is to perform a hydrologic assessment for the RMA onpost and offpost areas. This assessment includes development of a baseline program for hydrologic and contamination surveillance. Network design is followed by collection of surface water and ground water samples, measurement of hydrologic parameters, and chemical analysis of water

samples. These data will be evaluated to document the extent of contamination, the hydrologic and geologic conditions of the site, areas of public health exposure, potential contaminant migration pathways, and areas where additional data are required.

1.8.1 SCOPE-OF-WORK

The scope of the Task 44 water quality/quantity survey includes execution of a semiannual and/or quarterly ground water and surface water monitoring program capable of satisfying the various regulatory requirements, developing litigation-quality data to be added to the current data base, and assessing the extent and nature of contamination. In order to achieve these objectives, work in six distinct technical areas is anticipated. These areas are as follows:

- o Review of historical data;
- o Develop a monitoring program to achieve the objectives in Section 1.2;
- o Execute the monitoring program utilizing litigation-quality sampling and analytical procedures;
- o Assess data after the first sampling event for possible adjustments in the sampling and/or analytical scheme;
- o Compile and interpret the accumulated data at the end of the sampling program; and
- o Coordinate with and integrate data from other current ground water tasks such as Tasks 25, 26, 36, 38, and 39.

During review of the historical data, a large number of wells were evaluated with respect to construction detail, sampling history, and location. Criteria for evaluating these wells are described in Sections 3.1.1 through 3.1.2.

The following work was conducted to help design the Task 44 monitoring network. As previously discussed, this network will include wells from the 360° Monitoring Program, Basin F, and offpost sampling programs. Borehole logs and geologic cross sections were examined to establish a

preliminary evaluation of subsurface geology. Water-level data from the Task 4 program were examined to establish directions of ground water flow within the alluvium and to aid in the correlation of permeable units within the Denver Formation. Water-quality information from Task 4 and, as appropriate, from the historical data base were examined to formulate an assessment of the distribution of contaminants within the RMA ground water system. These contaminant distribution assessments will be modified as additional information is obtained and interpreted. A preliminary assessment of hydrogeologic conditions was used to design the proposed Task 44 well network. A detailed review of well selection methodology is discussed in Section 3.1.1.

All ground water monitoring wells and surface water sampling sites will be sampled using uniform sampling methods. Ground water and surface water samples will be analyzed for a predetermined list of analytes including numerous organic and inorganic parameters (Table 1.8-1). Sample collection, measurement of field parameters, and analysis of samples will be performed in accordance with USATHAMA Quality Assurance/Quality Control (QA/QC) procedures (USATHAMA, 1982, RIC#87048R03). These procedures include collection of field quality control samples and decontamination of all sampling equipment. Collection procedures are presented in Section 3.2 of this Technical Plan.

Table 1.8-1: Target Analytes - Task 44

Organochlorine Pesticides

- Aldrin
- Endrin
- Dieldrin
- Isodrin
- Hexachlorocyclopentadiene (CL6CP)
- PPDDE
- PPDDT

Volatile Organohalogens

- Chlorobenzene (CLC6H5)
- Chloroform (CHCL3)
- Carbon Tetrachloride (CCLA)
- trans-1,2-Dichloroethylene (T12DCE)
- Trichloroethylene (TRCLE)
- 1,1 Dichloroethylene (11DCE)
- 1,1 Dichloroethane (11DCLE)
- 1,2 Dichloroethane (12DCLE)
- 1,1,1 Trichloroethane (111TCE)
- 1,1,2 Trichloroethane (112TCE)
- Methylene Chloride (CH2CL2)
- Tetrachloroethylene (TCLEE)

Organosulfur Compounds

- P-Chlorophenylmethylsulfone ($CPMSO_2$)
- P-Chlorophenylmethylsulfoxide (CPMSO)
- P-Chlorophenylmethylsulfide (CPMS)
- 1,4-Dithiane
- Oxathiane
- Dimethyldisulfide (DMDS)

Volatile Aromatics

- Toluene
- Benzene
- Xylene (m-)
- Ethylbenzene
- Xylene (o-,p-)

DCPD/MIBK

- Dicyclopentadiene
- Methylisobutyl Ketone

DIMP/DMMP

- Diisopropylmethylphosphonate
- Dimethylmethylphosphonate

DBCP

- Dibromochloropropane

Metals

- Mercury
- Arsenic
- Cadmium
- Chromium
- Copper
- Lead
- Zinc

Major Cations

- Potassium
- Calcium
- Magnesium
- Sodium

Major Anions

- Chloride
- Fluoride
- Sulfate
- Nitrate+Nitrite
- Alkalinity (as $CaCO_3$)

Source: ESE, 1987

2.0 EVALUATION OF BACKGROUND DATA

2.1 DATA COMPILATION

A considerable effort has been made to compile and review regional and site-specific background information on RMA surface water and ground water hydrochemistry prior to preparation of this Technical Plan. This effort included tabulating and reviewing data obtained during previous RMA field investigations, as well as completing detailed literature reviews. Historical analyte concentrations were obtained from the USATHAMA data base which contains chemical data for RMA wells sampled between 1975 and early 1986, including some data obtained during Task 4 and other recent RMA ground water monitoring programs. All information in this data base has passed through USATHAMA QA/QC data acceptance routines. Information including well construction records, past sampling procedures, and additional analytical data obtained from RMA files and the RMA data base were also reviewed during the compilation effort. Although the efforts completed to date have been significant, data compilation and review will continue as an ongoing process as additional field data is collected and incorporated in RMA data files and the USATHAMA data base.

2.1.1 SITE RECONNAISSANCE/MEETINGS

Internal contractor meetings for Task 44 were held in Denver on February 25, 1987, and March 16, 1987. The purpose of these meetings was to allow the project team to discuss the scope of work and project objectives and to begin assembling data. Following the contract award on March 19, 1987, a meeting was held with Program Manager's Office (PMO-RMA) personnel to clarify Task 44 objectives and scope of work.

As a result of previous task orders, the project team was familiar with key RMA personnel and operational procedures; therefore, meetings with PMO-RMA personnel were devoted primarily to discussion of details and schedules. Because of the project team's familiarity with RMA, site reconnaissance was deemed unnecessary for Task 44. This activity was performed during and

prior to Task 4, when site reconnaissance was utilized to verify the existence and location of wells prior to sampling activities. A reconnaissance of surface water monitoring structures was performed on June 25, 1985, to determine the efforts required to recondition and repair existing monitoring facilities and structures.

3.0 GEOTECHNICAL PROGRAM

The Task 44 geotechnical program will provide high quality data to supplement the current litigation quality database. As designed, the program will conduct the necessary activities to acquire this data so that task objectives can be achieved as defined in Section 1.0. The geotechnical program is designed to be dynamic, and may be modified in response to program objective changes.

3.1 GROUND WATER MONITORING PROGRAM

Task 44 ground water monitoring activities include measurement of water levels and collection of water samples for water quality analyses. The Task 44 geotechnical program design follows the technical elements established in the Task 4 program.

3.1.1 NETWORK DESIGN

Existing information on monitoring well construction, sampling history, well locations relative to contaminant distribution, regulatory compliance, and previous Task 4 well evaluations were used to evaluate a well and determine if it was suitable for inclusion in the Task 44 monitoring network.

This existing information was used to:

- Identify wells with construction suitable for water quality sampling and wells suitable for water level measurements;
- Identify wells that cannot be sampled because they are dry or have obstructions, broken casing, etc.;
- Identify wells with documented sampling histories;
- Identify wells with optimum locations relative to contaminant concentrations, locations of well clusters, and wells in areas with possible uncontaminated ground water; and
- Identify wells that were or are being used in compatible RMA ground water monitoring programs, such as Tasks 4, 25, 38, etc.

All onpost wells with sufficient historical information were subjected to an initial construction evaluation under Task 4. A second construction evaluation was conducted under Task 44 and modified the Task 4 list. Wells passing the Task 44 construction evaluation were then subjected to sampling history and location (relative to contaminant distribution, etc.) evaluations. Results of these evaluations were integrated to determine suitability for inclusion in the Task 44 network. A flow chart describing the Task 44 well selection process is shown in Figure 3.1-1.

The purpose of this rigorous evaluation process is to produce the most accurate litigation quality data so that Task 44 objectives will be achieved. Wells selected for inclusion in the Task 44 network basically include wells from Tasks 4, 25, and 38 programs. Wells are also included that address data deficiencies, and reflect relevant SCC, Colorado Department of Health (CDH), and Environmental Protection Agency (EPA) comments. Offpost wells included in the Task 44 network were selected from the Revision III - 360° Monitoring Program and included new monitoring wells installed under offpost Task 6 (under Contract No. DAAK11-8?-D-0007).

The following sections detail the well selection process. Sections discuss well construction evaluation, sampling, history evaluation, and location evaluation.

3.1.1.1 Well Construction Evaluation

Well construction evaluations were completed under Task 4, and the results of these evaluations were used in Task 44 efforts. Summary information for over 1,500 wells occurs in the RMA Observation Well Summary Report (Obswell Report) (D.P. Associates, 1985, RIC#85183R01), and this information was used in initial phases of Task 4 evaluations. Approximately one-third of these wells were not evaluated with respect to construction because the Obswell Report contained insufficient borehole and well completion information, or the well had been abandoned. The number of wells falling into these categories are listed below:

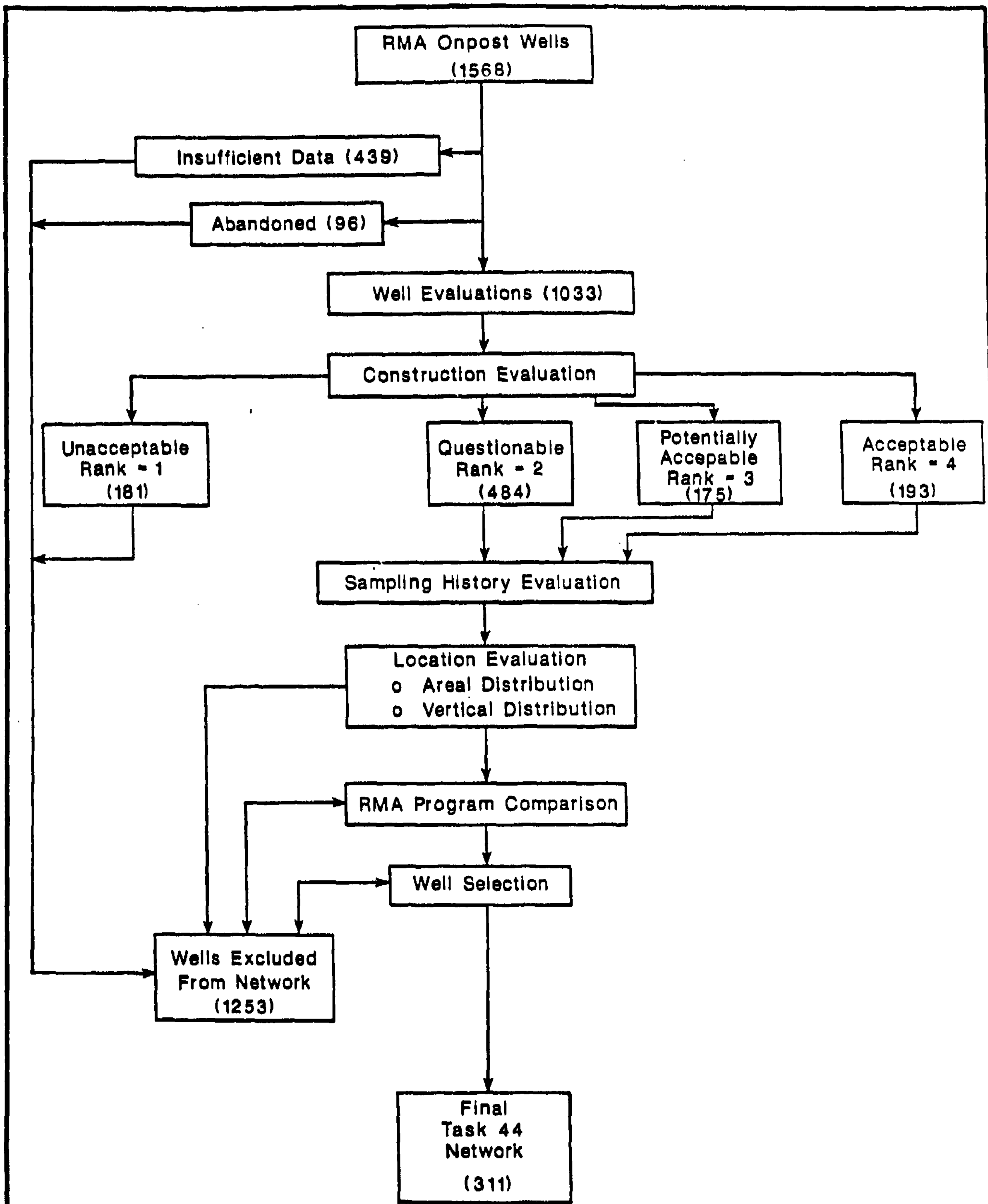


Figure 3.1-1
WELL SELECTION AND EVALUATION PROCESS

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

Wells with insufficient data	=	443
Abandoned wells	=	96
Balance of wells evaluated	=	1,029
TOTAL		1,568

Construction records of the 1,029 remaining wells were evaluated in detail to determine the following:

- Drilling and completion procedures;
- Location and collar elevation accuracy;
- Casing cap and locking cap details;
- Surface seal type and interval;
- Blank interval backfill material;
- Screen type and length;
- Aquifer(s) within the screen interval;
- Relation of the screen interval to water levels;
- Relation of the screen interval to aquifer thickness;
- Sand pack type and interval;
- Type and thickness of seal above sand pack;
- Relation of seal to aquifer limits;
- End plug and silt-trap detail; and
- Documentation of construction data.

Information was obtained from the USATHAMA and RMA databases and from boring and well completion logs on file at the RMA-ED. To expedite this evaluation and provide consistent results, a standardized evaluation sheet was completed for each well (Table 3.1-1). These sheets were used for comparative purposes only and were not intended for use in rating well constructions or in eliminating individual wells.

Task 4 construction evaluation criteria placed the 1,029 ground water monitoring wells into four groups with numerical designations as follows: (1) unacceptable, (2) questionable, (3) potentially acceptable, and (4) acceptable. These categories are based on construction quality and the degree of well construction documentation. Because they were assigned largely on the presence or absence of supporting documentation, the rankings

Table 3.1-1. Well Construction Factors

Section No.____________ Well No._____________

Construction Factors				
Aquifer	Upper (Alluvial)	Lower (Denver)	Both	Unknown
Location	Surveyed	Approximated From Map	Approximated in Field	Unknown
Collar Elevation	Surveyed	Approximated From Map	Approximated In Field	Unknown
Locking Cap	Yes	Secured Area	No	Unknown
Surface Seal Type	Grout	Bentonite	Soil	Unknown
Surface Seal Interval	≥10 ft	<10 ft	None	Unknown
Blank Interval Backfill	Grout	Soil	Sand	Unknown
Casing Type	Teflon/Stainless	Threaded PVC	Glued PVC	Unknown
Casing Size	≥6 in	4 in	2-2.5 in	Unknown
Screen Type	Well Screen	Factory Slotted	Field Slotted	Unknown
Screen Length	>20 ft	10-20 ft	<10 ft	Unknown
Screen Interval	Sand	Sand/Clay	Clay	Unknown
Screened Zone	Full Penetration	Partial Penetration	Multiple Aquifer	Unknown
Relation to Water Level	Within Screened Interval	Above Screen	Below Screen	Unknown
Sand Pack Type	Industrial Sand	Pea Gravel	Natural	Unknown
Sand Pack Interval	Above Screen	At Top of Screen	Below Screen	Unknown
Seal Above Sand Pack	Grout	Bentonite	Soil	Unknown
Seal Above Sand Pack Interval	≥10 ft	<1 ft	None	Unknown
End Plug	Threaded	Glued	None	Unknown
Silt Trap	≥1 ft	<1 ft	None	Unknown
Construction Data	Detailed as Built Data	Approximate as Built Data	Work Plan	Unknown
Drilling Method	Auger	Rotary	Conductor Casing	Unknown
Evaluation				
Data Reliability	Excellent	Good	Fair	Poor
Data Accuracy	≤1 ft	1-5 ft	>5 ft	Unknown
Recommendation for Monitoring	Acceptable	Possible Acceptable	Questionable	Abandon
Usefulness for Specific Contaminants	Organic Monitoring	Inorganic Monitoring	Water Level	None
Recommendation for Water Level Measurement	Acceptable	Possibly Acceptable	Questionable	Abandon

Remarks:

Source(s) of Data:

Summary Prepared By: Date Prepared:

Summary Checked By: Date Checked:

in = inch; ft = feet

Source: ESE, 1987

are not intended to imply that a "questionable" well designation is a well with questionable construction or chemistry. Instead, insufficient data were found to merit a higher ranking.

Results of the Task 4 construction evaluation are summarized below:

Wells of acceptable (Rank = 4) construction	= 189
Wells of potentially acceptable (Rank = 3) construction	= 175
Wells of questionable (Rank = 2) construction	= 484
Wells of unacceptable (Rank = 1) construction	= 181
TOTAL	1,029

This Task 4 ranking was used as the basis for Task 44 well construction evaluations. Wells were reclassified during design of the Task 44 network if additional construction information was found, and newly constructed wells were also added to the ranking. Results of this Task 44 re-evaluation are summarized below and in Tables 3.1-2 through 3.1-5:

Wells of acceptable construction (Rank = 4)	= 193
Wells of potentially acceptable construction (Rank = 3)	= 175
Wells of questionable construction (Rank = 2)	= 484
Wells of unacceptable construction (Rank = 1)	= 181
TOTAL	1,033

3.1.1.2 Sampling History Evaluation

A sampling history evaluation was conducted under Task 4 for wells ranked acceptable and potentially acceptable, and for selected questionably ranked wells in the 360° Monitoring and Basin F programs. The results of this initial evaluation were updated with Task 4 water quality data in Task 44 efforts.

The purpose of these evaluations was to identify monitoring wells that exhibited:

- o Long-term sampling histories;
- o Elevated contaminant concentrations;
- o Consistent contaminant concentrations;
- o Trends in contaminant concentrations; and
- o Erratic or anomalous chemistry.

Table 3.1-2. Ground Water Wells of Acceptable Construction (Rank = 4)
(Page 1 of 2)

Section	Well Numbers
1	21, 22, 23, 24, 25, 26, 27, 28, 29, 31, 32, 34, 35
2	9, 10, 11, 12, 13, 15, 16, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 30, 31
3	2, 3, 4, 5, 6, 7
4	7, 8, 9, 10, 11, 12, 26, 27, 28, 29
5	2, 3
6	3, 4, 5
7	4, 5
8	3, 4, 5
9	2, 3, 4
11	2, 4
12	2, 3, 4
19	14, 15, 16, 17, 18, 19
22	23, 24, 27, 28, 30, 31, 49, 60
23	177, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193
24	159
25	8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
26	145, 146, 147
27	53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 73, 74, 76, 77, 78, 83

Table 3.1-2. Ground Water Wells of Acceptable Construction (Rank = 4)
(Continued, Page 2 of 2)

Section	Well Numbers
28	25, 28, 29
29	2, 3
30	3, 4, 5, 6, 7, 8, 9, 10, 11
31	5, 6, 7, 8, 9, 10, 11
32	2, 3
33	26, 27, 28, 29, 30, 31, 32, 33, 34, 35
34	2, 3, 4, 5, 6, 7, 8, 9, 10
35	52, 53, 54, 55, 56, 58, 59, 60, 61, 62, 63, 65, 66, 67, 68, 69, 70
36	1, 116, 118, 121

Total Wells = 193

Source: ESE, 1987

Table 3.1-3. Ground Water Wells of Potentially Acceptable Construction (Rank = 3)

Section	Well Numbers
1	30, 33, 36, 37, 38, 39, 40, 41, 42, 43, 47, 48, 49, 50
2	14, 17, 32, 33, 34, 35, 36, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49
7	3
11	3
22	20, 21, 22, 25, 26, 29, 33, 34, 36, 37, 38, 39, 40, 41, 42, 43, 45, 53, 56, 58, 59
23	7, 28, 161, 166, 176, 196, 197, 198, 200, 201, 203, 204, 205, 211, 336, 337, 338, 339, 340, 341, 342
24	1, 2, 136, 149, 150, 158, 161, 162, 163, 164, 170, 171, 172, 173, 174, 175, 176, 178, 179, 183, 184, 185, 188, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354
25	4, 21, 22, 23, 24, 25, 26, 29, 35, 36, 37, 38, 39, 40
26	135, 140, 141, 142
27	64, 66, 68, 69, 70, 71, 72
28	26
33	48, 49, 50, 51, 52, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69
35	71, 72
36	112, 113, 114, 117, 119, 122, 136, 137, 138, 139, 140, 141, 142, 146, 147

Total Wells = 175

Source: ESE, 1987

Table 3.1-4. Ground Water Wells of Questionable Construction (Rank = 2) (Page 1 of 2)

Section	Well Numbers
1	1, 2, 3, 4, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 18, 19, 20
2	1, 2, 3, 4, 5, 6, 7, 8, 37
3	1
6	1, 2
7	1
8	2
11	1
12	1
19	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
20	1
22	2, 3, 4, 6, 8, 12, 13, 14, 15, 16, 17, 18, 19, 44, 51, 52, 54, 55, 57
23	2, 4, 8, 9, 10, 11, 13, 14, 15, 29, 32, 34, 35, 36, 39, 41, 42, 47, 48, 49, 52, 53, 54, 56, 57, 58, 59, 61, 63, 64, 66, 67, 96, 109, 110, 111, 118, 119, 120, 121, 122, 123, 128, 136, 137, 139, 140, 141, 142, 143, 144, 145, 146, 148, 149, 150, 151, 157, 158, 159, 160, 178, 199, 202, 206, 207, 209. 210
24	3, 6, 13, 25, 27, 47, 49, 53, 57, 58, 63, 80, 81, 83, 85, 86, 87, 89, 90, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 121, 122, 123, 124, 126, 127, 128, 129, 130, 135, 151, 165, 166, 167, 168, 169, 171, 177, 180, 181, 182, 186, 187
25	3, 5, 6, 7, 30, 31, 34

Table 3.1-4. Ground Water Wells of Questionable Construction (Rank = 2) (Continued, Page 2 of 2)

Section	Well Numbers
26	1, 2, 4, 5, 9, 11, 13, 14, 16, 18, 19, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 40, 41, 42, 43, 44, 45, 46, 47, 48, 50, 51, 52, 53, 54, 55, 56, 57, 58, 60, 61, 62, 63, 64, 65, 66, 67, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 83, 84, 85, 87, 86, 88, 89, 90, 91, 92, 93, 94, 96, 97, 119, 123, 124, 126, 127, 128, 129, 131, 132, 133, 136, 138, 139, 143, 144
27	2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 15, 17, 18, 19, 25, 27, 28, 29, 30, 31, 32, 33, 34, 37, 40, 41, 42, 43, 44, 45, 49, 50, 51, 52, 63, 65, 75, 79, 80, 81, 82
28	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 14, 15, 16, 18, 20, 22, 23, 24, 27
31	2, 3
32	1
33	1, 2, 16, 18, 19, 20, 21, 22, 23, 24, 25, 53, 54
35	2, 3, 5, 6, 7, 8, 9, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 47, 48, 50, 51, 73, 74, 76
36	3, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 21, 22, 23, 24, 25, [illegible] 29, 30, 31, 32, 33, 34, 35, 36, 43, 48, 50, 55, 56, [illegible]1, 62, 63, 65, 66, 67, 68, 69, 72, 73, 74, 75, 76, [illegible], 78, 79, 81, 83, 84, 85, 86, 87, 88, 90, 91, 103, 1[illegible], [illegible]07, [illegible]8, 109, 110, 145

Total Wells = 484

Source: ESE, 1987

Table 3.1-5. Ground Water Wells of Unacceptable Construction (Rank = 1)

Section	Well Number
5	1
22	1, 9, 10, 32
23	3, 6, 38, 40, 49, 50, 55, 60, 62, 65, 95, 108, 127, 132, 151, 301, 302, 303, 304, 305, 330, 331, 332, 333, 334, 335
24	4, 7, 8, 9, 10, 28, 43, 45, 46, 48, 50, 51, 52, 54, 55, 64, 65, 84, 88, 91, 137, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438
25	1, 2, 27, 28, 33
26	6, 10, 15, 17, 20, 42, 49, 98
27	1, 8, 14, 16, 20, 21, 22, 23, 24, 26, 35, 36
28	10, 16, 17, 19, 21
30	1, 2
31	1, 4
33	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
34	1
35	1, 4, 10, 19, 24, 42, 43, 44, 45, 46, 49
36	2, 12, 37, 38, 39, 40, 41, 42, 44, 45, 46, 49, 53, 58, 59, 64, 70, 71, 82, 101, 102, 106

Total Wells = 181

Source: ESE, 1987

Several factors were examined and documented for each well including historical chemical data, frequency of sampling, period of record, analyte variation, water level data, and well status with respect to current RMA programs.

Chemical Data

Evaluation of chemical data included contaminant identification, frequency and magnitude of these detections, and chemical trends. Contaminant patterns or trends were described as increasing or decreasing, and as consistently high or consistently low.

Most wells exhibited consistent concentration trends with respect to inorganic contaminants and organic contaminants of high solubility and low volatility. However, these same wells exhibited variable concentrations for organic contaminants that were present at concentrations near the compound's method detection limit. Concentration variations for organic contaminants near the method detection limits most likely result from inherent variability in the analytical techniques or laboratory variations.

Sampling Frequency and Period of Record

Many wells do not possess regular, detailed sampling histories that were collected over an extended period of time. For example, many wells were sampled on a semiannual, quarterly, or even more frequent basis for a period of one to two years, but then were not sampled for several years. In many cases, the wells were sampled with a different frequency (i.e., annually) several years later. Much of this variation in sampling histories apparently resulted from logistical constraints at RMA. Some wells with extensive sampling history do not have sufficient well construction information, while newer wells with documented well construction do not have extensive sampling histories. These variations in sampling histories and discrepancies in chemical data prevented a straightforward interpretation of contaminant trends. Wells from this historical data group were included in Task 44 where additional coverage or more detail was deemed appropriate based on evaluation of Task 4 data.

Water Level Data

The final step in the sampling history examination was to evaluate water-level data obtained for each well. Water levels were monitored in approximately 875 wells on a quarterly basis as part of Tasks 4 and 25. The goal of the Task 44 evaluation was to identify wells suitable for water level measurement that would produce a network to satisfy program objectives. Wells that displayed consistent water levels, rising or falling trends, seasonal variations or irregular results and, most importantly, well clusters that showed hydraulic differences between water-bearing zones were determined. Period of record, frequency of past measurements, and relation to current water level measuring programs were also evaluated for each well.

3.1.1.3 Location Evaluation

Location evaluation was conducted for the ground water monitoring network under Task 44. This study evaluated the areal well distribution to identify wells that have optimum locations relative to contaminant distributions and regional hydrogeologic data requirements.

Individual Wells

Individual well placements were examined during the location evaluation to ensure that (1) the most probable flow paths in and out of a potential contaminant site had been monitored, (2) areas with significant contaminant flow and contaminant concentration variation had been monitored, (3) background and worst case conditions had been evaluated, and (4) a sufficient density of wells existed to define the lateral and vertical extent of contamination.

Initially, the areal distribution of wells of acceptable or potentially acceptable ranking were examined in respect to above criteria. In areas with dense coverage, wells were preferentially selected from the acceptable and potentially acceptable categories. Areas with insufficient well coverage, incomplete transects across or along major flow paths, or areas with dense coverage outside of major flow paths (i.e., bedrock highs) were identified. Wells with questionable construction details were considered for inclusion in areas of insufficient coverage where acceptable or potentially acceptable wells did not exist.

The areal distribution of wells was compared to known ground water contaminant patterns (Figure 1.7-1) and the location of known and potential contaminant sites. Areas were identified within which an insufficient number of acceptable or potentially acceptable wells were available relative to contaminant patterns, and available wells designated as questionable were selected to infill data gaps. Areas were also defined where additional monitoring wells may need to be installed under the Composite Well Program.

Well Clusters

Wells that were part of well clusters were identified to examine the vertical distribution of contaminants. Well clusters are defined as two or more wells within a 50-ft circle with at least one well screened in the Denver Formation and one in the alluvium. Well clusters were ranked in accordance with the same criteria as previously described for individual wells. Well clusters are considered important in the selection process because they provide information on the hydraulic and chemical variations between water-bearing zones at a particular location. By using well clusters, a three dimensional chemical and hydrogeologic picture can be developed. When considering clustered wells screened within Denver Formation sand units, historical water-quality data was used to select the well or wells to be monitored. Where the deepest Denver interval sampled contained contaminants above guidance levels, this well was included in the network and recommendations made for a deeper well at that location. At well cluster sites where there is a decrease in contaminant concentrations with depth, wells containing contaminant levels below guidance criteria were generally not included in the network unless geologic or hydrologic conditions suggested that ground water quality monitoring was justified.

Geologic and hydrologic conditions in the vicinity of the cluster wells were considered in order to evaluate possible hydraulic communication between areas and to help select the most desirable wells. The local horizontal flow direction was considered in conjunction with the monitored interval in each well to select appropriate downgradient monitor wells. The overall distribution of clusters was evaluated to identify areas of dense coverage or duplication of clusters.

3.1.2 SELECTION OF THE MONITORING NETWORK

3.1.2.1 Overview of Onpost and Offpost Networks

The proposed long-term monitoring network for RMA consists of a total of 311 alluvial, Denver Formation, and offpost wells. Well locations are shown in Figures 3.1-2 to 3.1-4. Of the 311 wells, 43 are located in the offpost area and 268 wells have either been recently sampled or are proposed for sampling under other RMA tasks or programs as listed below.

- 186 Task 4 wells (includes 6 wells previously included with Task 38);
- 43 Offpost wells;
- 25 Task 25 wells;
- 11 Task 38 wells; and
- 46 Historic and recent SCC wells.

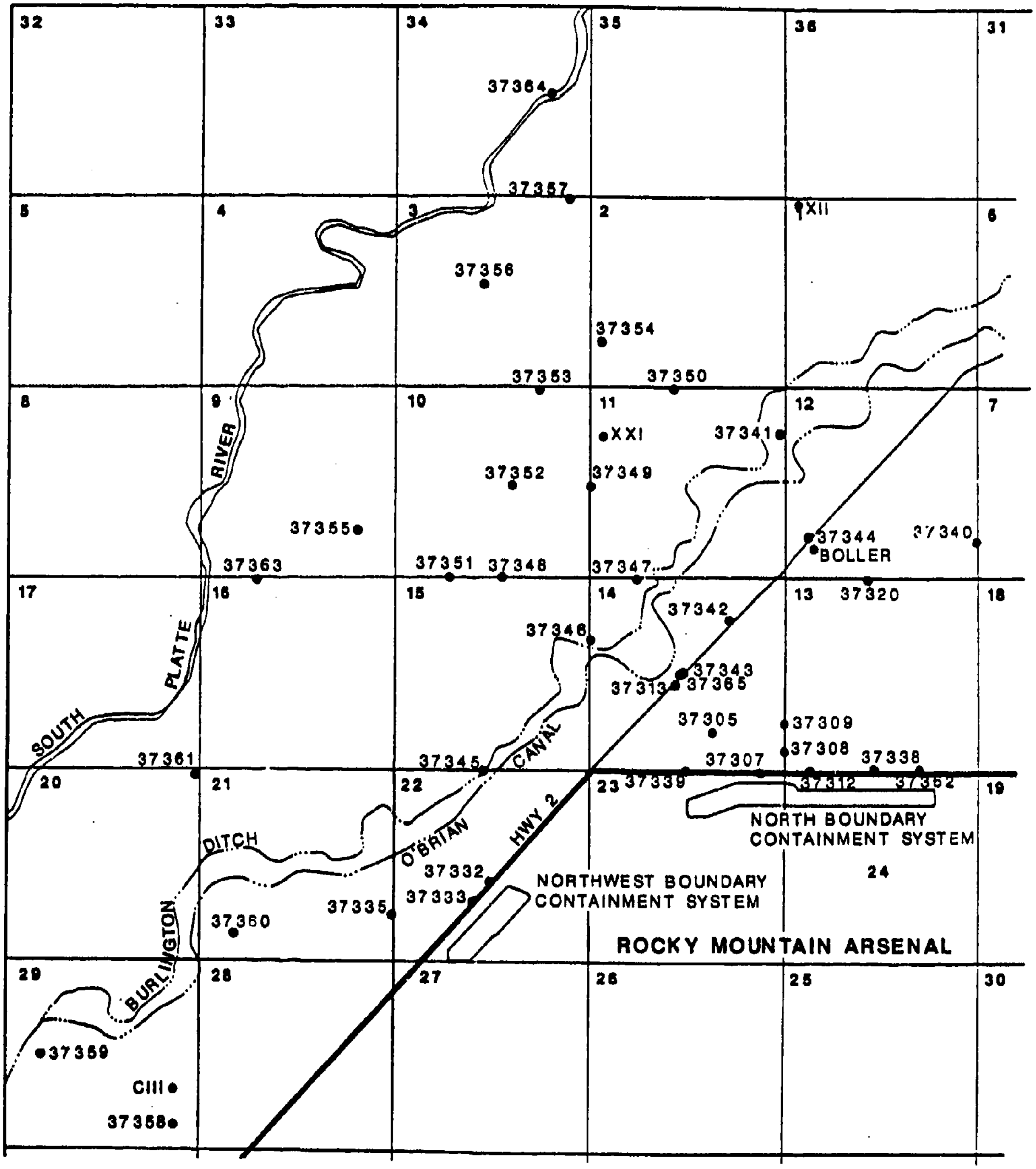
311 Wells

Historic wells are those not sampled recently. Specific wells selected for the Task 44 network from other task networks are discussed in Section 3.1.2.5.

Except for offpost well locations, all wells were selected utilizing the criteria and methodology described previously in Section 3.1.1 and illustrated in Figure 3.1-1. A listing of the wells is given in Table 3.1-6 (offpost), 3.1-7 (onpost alluvial), and 3.1-8 (onpost Denver Formation).

3.1.2.2 Offpost Water Quality Monitoring Network

The offpost monitoring network consists of 43 wells from offpost Task 6 (Contract No. DAAK11-83-D-007) as listed in Table 3.1-6 and shown in Figure 3.1-2. Well selection criteria were not evaluated in depth for offpost wells because these wells were taken directly from Revision III - 360° Monitoring Program. Of the 43 total offpost wells, 42 are completed in alluvium and one is considered a Denver Formation well. Offpost and onpost wells will be sampled and analyzed using identical procedures (Section 3.2 and 4.0). Offpost wells will be sampled on a quarterly basis in conjunction with Task 25 and to comply with requirements of the 1975 Cease and Desist



Note: Off-Post Well 37366 Is Southeast of RMA, See Figures 7, 8, and 9
37365 Denver Formation Well

Figure 3.1-2
PROPOSED OFF-POST TASK 44 ALLUVIAL AND DENVER WELL MONITORING NETWORK
SOURCE: HLA, 1987

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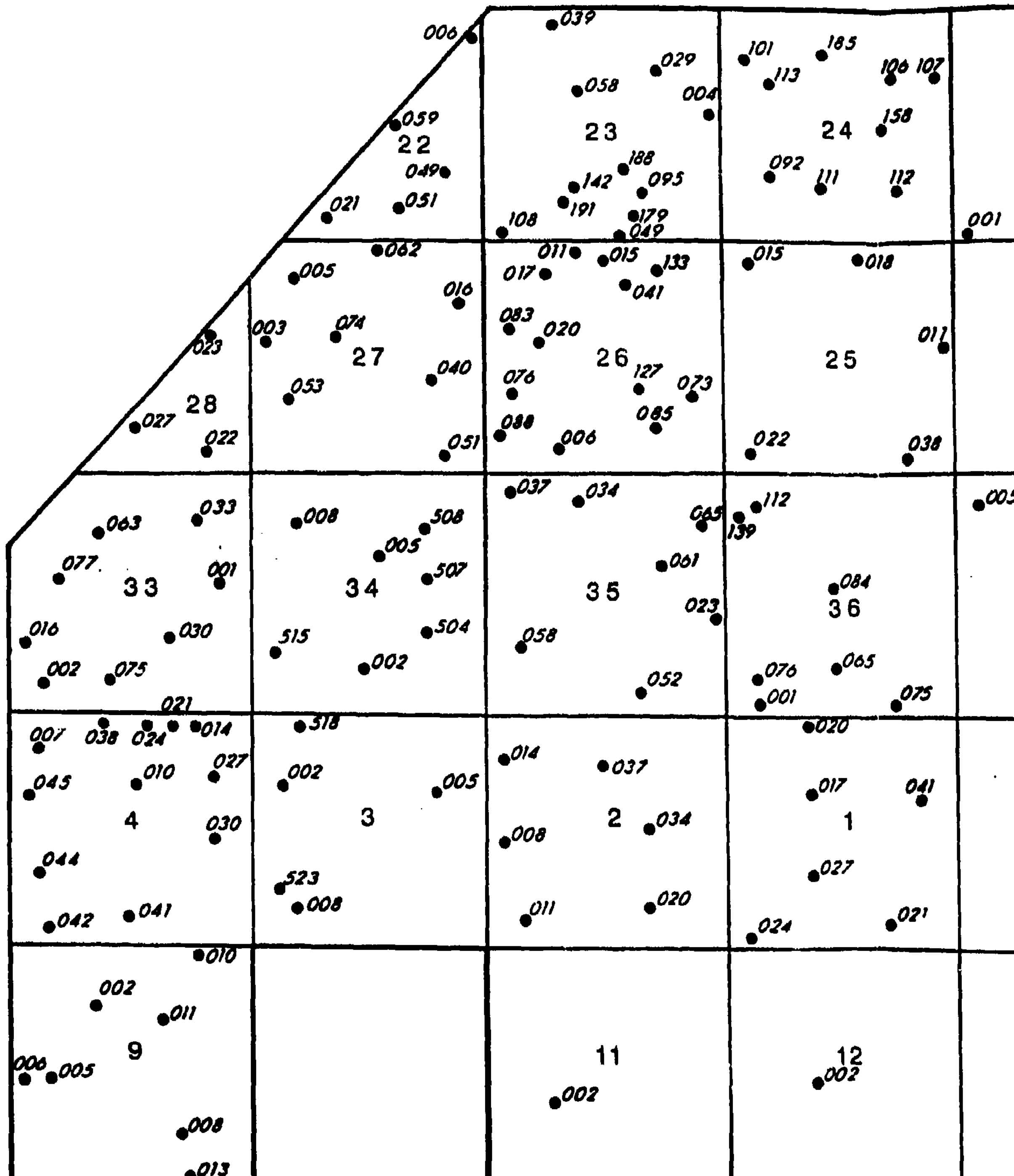
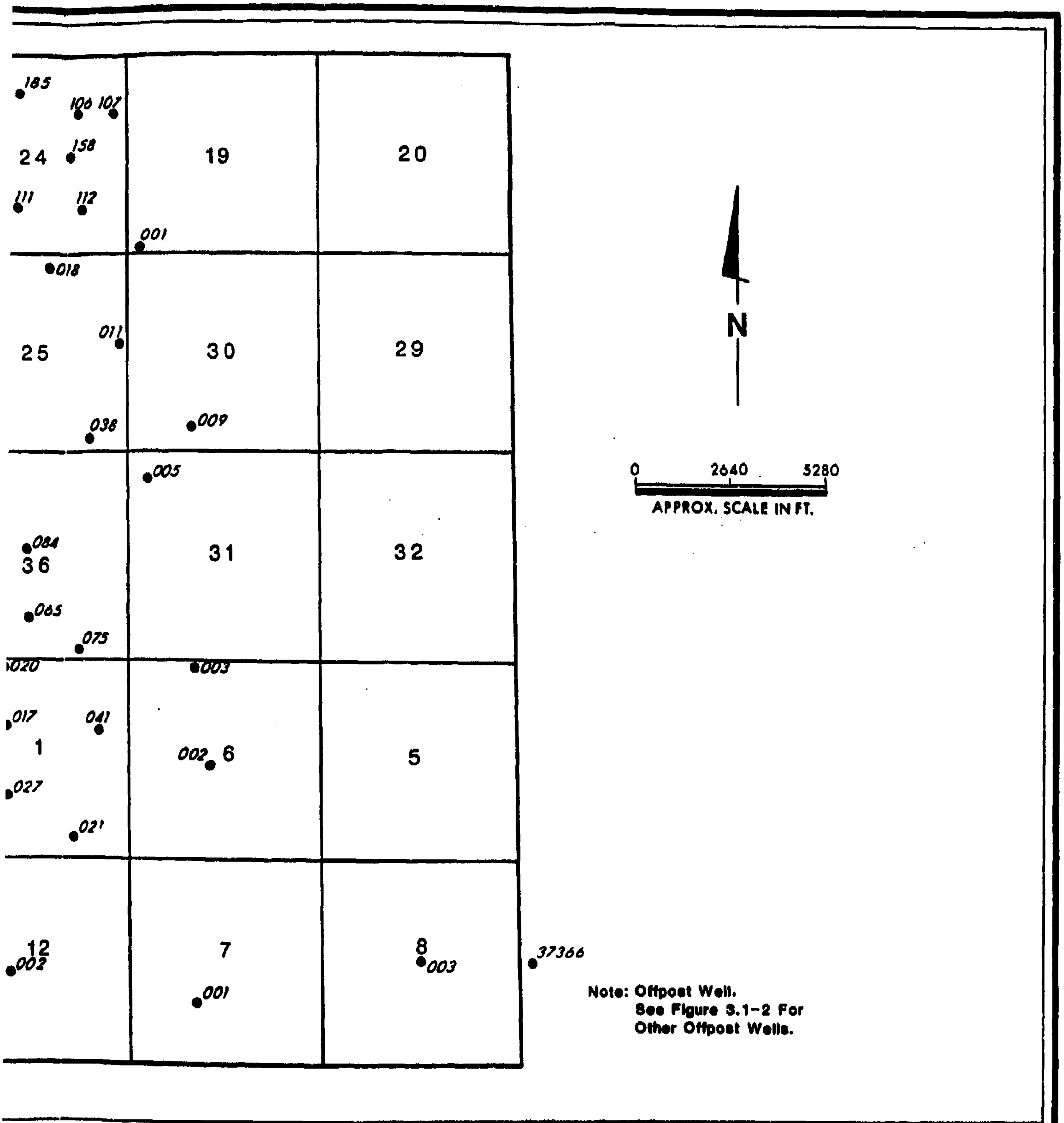


Figure 3.1-3
PROPOSED TASK 44 ONPOST ALLUVIAL MONITORING WELL NETWORK

SOURCE : HLA, 1987



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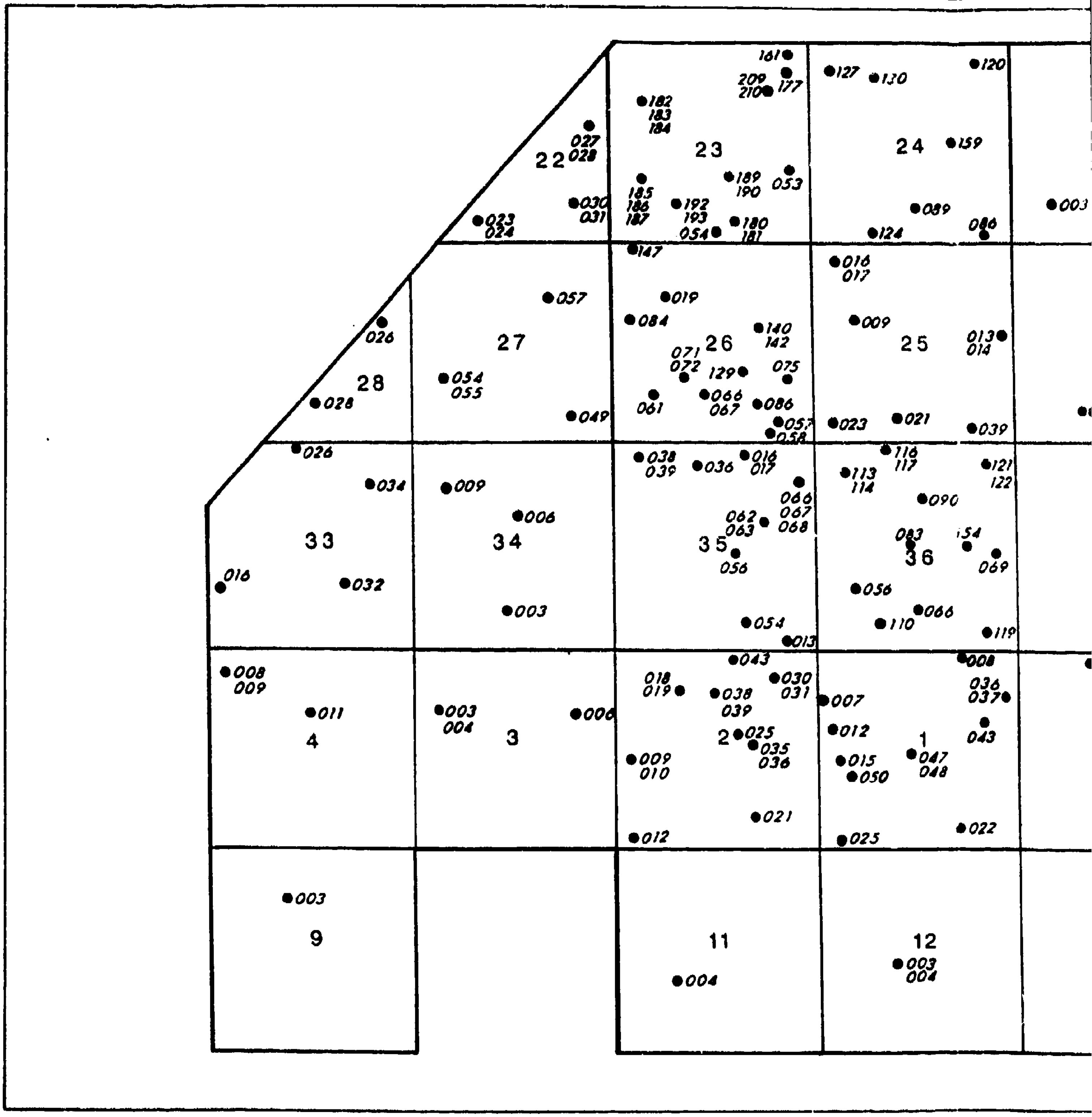
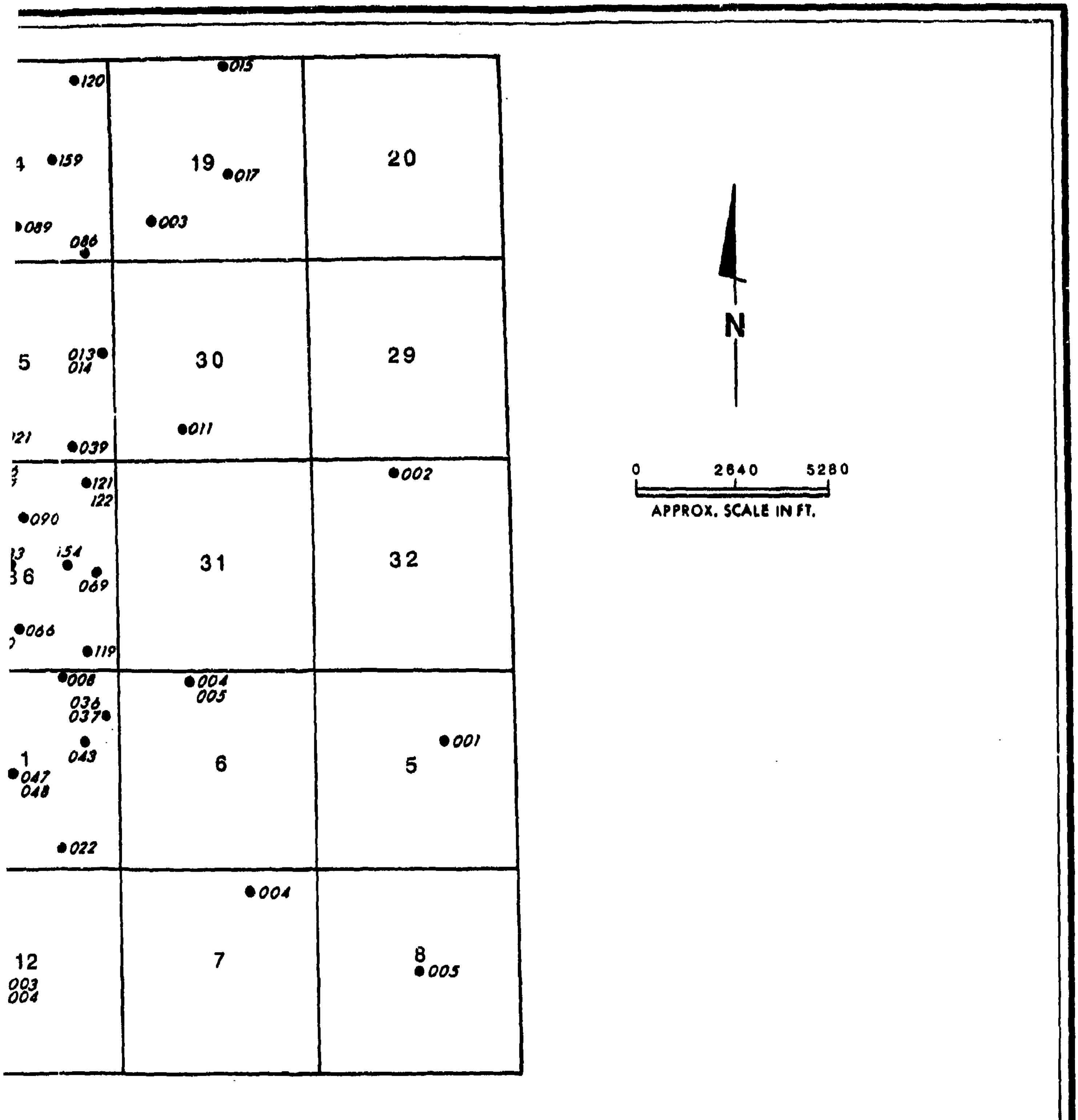


Figure 3.1-4
PROPOSED TASK 44 ONPOST DENVER FORMATION MONITORING WELL NETWO

SOURCE: HLA, 1987



WELL NETWORK

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Table 3.1-6. Task 44 Offpost Well Network

37305*	37348
37307	37349
37308	37350
37309	37351
37312	37352
37313	37353
37320	37354
37332	37355
37333	37356
37335	37357
37338	37358
37338	37359
37340	37360
37341	37361
37342	37362
37343	37363
37344	37364
37345	37365**
37346	37366
37347	

Also included are the following four alluvial domestic wells:

Boller
XII
XXI
CIII

* Well abandoned.
** Denver Formation well.

Source: ESE, 1987

Table 3.1-7. Proposed Onpost Task 44 Monitoring Network, Alluvial Aquifer Wells (Page 1 of 2)

Section	Total Wells	Well Numbers
1	6	017, 020, 021, 024, 027, 041
2	6	008, 011, 014, 020, 034, 037
3	5	002, 005, 008, 518, 523
4	12	007, 010, 014, 021, 024, 027, 030, 038, 041, 042, 044, 045
6	2	002, 003
7	1	001
8	1	003
9	7	002, 005, 006, 008, 010, 011, 013
11	1	002
12	1	002
19	1	001
22	5	006, 021, 049, 051, 059
23	11	004, 029, 039, 049, 058, 095, 108, 142, 179, 188, 191
24	9	092, 101, 106, 107, 111, 112, 113, 158, 185
25	5	011, 015, 018, 022, 038
26	13	006, 011, 015, 017, 020, 041, 073, 076, 083, 085, 088, 127, 133
27	8	003, 005, 016, 040, 051, 053, 062, 074
28	3	022, 023, 027

Table 3.1-7. Proposed Onpost Task 44 Monitoring Network, Alluvial Aquifer Wells (Continued, Page 2 of 2)

Section	Total Wells	Well Numbers
30	1	009
31	1	005
33	8	001, 002, 030, 033, 039, 063, 075, 077
34	7	002, 005, 008, 504, 507, 508, 515
35	7	023, 034, 037, 052, 058, 061, 065
36	7	001, 065, 075, 076, 084, 112, 139

Note:

Task 4 Wells	84
Current Task 25 Wells	15
Task 38 Wells	11
Historic Wells	15
Recent Shell Wells	3
Total Task 44 Wells	128

Source: ESE, 1987

Table 3.1-8. Proposed Onpost Task 44 Monitoring Network
Denver Formation Wells (Page 1 of 2)

Section	Total Wells	Well Numbers
1	12	007, 008, 012, 015, 022, 025, 036, 037, 043, 047, 048, 050
2	14	009, 010, 012, 018, 019, 021, 025, 030, 031, 035, 036, 038, 039, 043
3	3	003, 004, 006
4	3	008, 009, 011
5	1	001
6	2	004, 005
7	1	004
8	1	005
9	1	003
11	1	004
12	2	003, 004
19	3	003, 015, 017
22	6	023, 024, 027, 028, 030, 031
23	18	053, 054, 161, 177, 180, 181, 182, 183, 184, 185, 186, 187, 189, 190, 192, 193, 209, 210
24	7	086, 089, 120, 124, 127, 130, 159
25	8	009, 013, 014, 016, 017, 021, 023, 039
26	15	019, 057, 058, 061, 066, 067, 071, 072, 075, 084, 086, 129, 140, 142, 147
27	4	049, 054, 055, 057

Table 3.1-8. Proposed Onpost Task 44 Monitoring Network
Denver Formation Wells (Continued, Page 2 of 2)

Section	Total Wells	Well Numbers
28	2	026, 028
30	1	011
32	1	002
33	4	016, 026, 032, 034
34	3	003, 006, 009
35	13	013, 016, 017, 036, 038, 039, 054, 056, 062, 063, 066, 067, 068
36	14	056, 066, 069, 083, 090, 110, 113, 114, 116, 117, 119, 121, 122, 154

Note:	Current Task 25 Wells	10
	Task 4 Wells	102
	Historic Wells	28
	Total Task 44 Wells	140

Source: ESE, 1987

Order. Additional monitoring of the Denver Formation offpost will be performed under Tasks 25, 36, and 39. These tasks include installation of additional Denver Formation monitoring wells in selected locations.

3.1.2.3 Onpost Water Quality Monitoring Network

The onpost monitoring network has been subdivided into an alluvial network consisting of 128 wells and a Denver Formation network consisting of 140 wells. These networks are discussed separately below. Onpost sampling will be conducted semiannually except for the following 12 wells in the vicinity of Basin F which will be sampled quarterly:

23049	23142	26020	26085
23095	26015	26041	26127
23108	26017	26073	27016

Quarterly sampling was conducted historically for these Basin F wells, and the same sampling schedule was retained in Task 44 efforts to provide consistent sampling frequency.

Alluvial Well Network

The alluvial monitoring well network was designed to monitor contaminant distributions in saturated RMA alluvium. One hundred and twenty-eight onpost alluvial wells were selected for the Task 44 program (Table 3.1-7). Many of these wells have been sampled within the last year under current or previously existing RMA tasks:

Task 4 wells	84
Current Task 25 wells	15
Current Task 38 wells	11
Historical wells	15
Recent Shell Wells	3
Total Task 44 Wells	128

The alluvial monitoring well network is shown in Figure 3.1-3 and summarized by section in Table 3.1-7. Large portions of RMA have unsaturated alluvium, and Figure 3.1-5 illustrates alluvial well locations with respect to unsaturated alluvium.

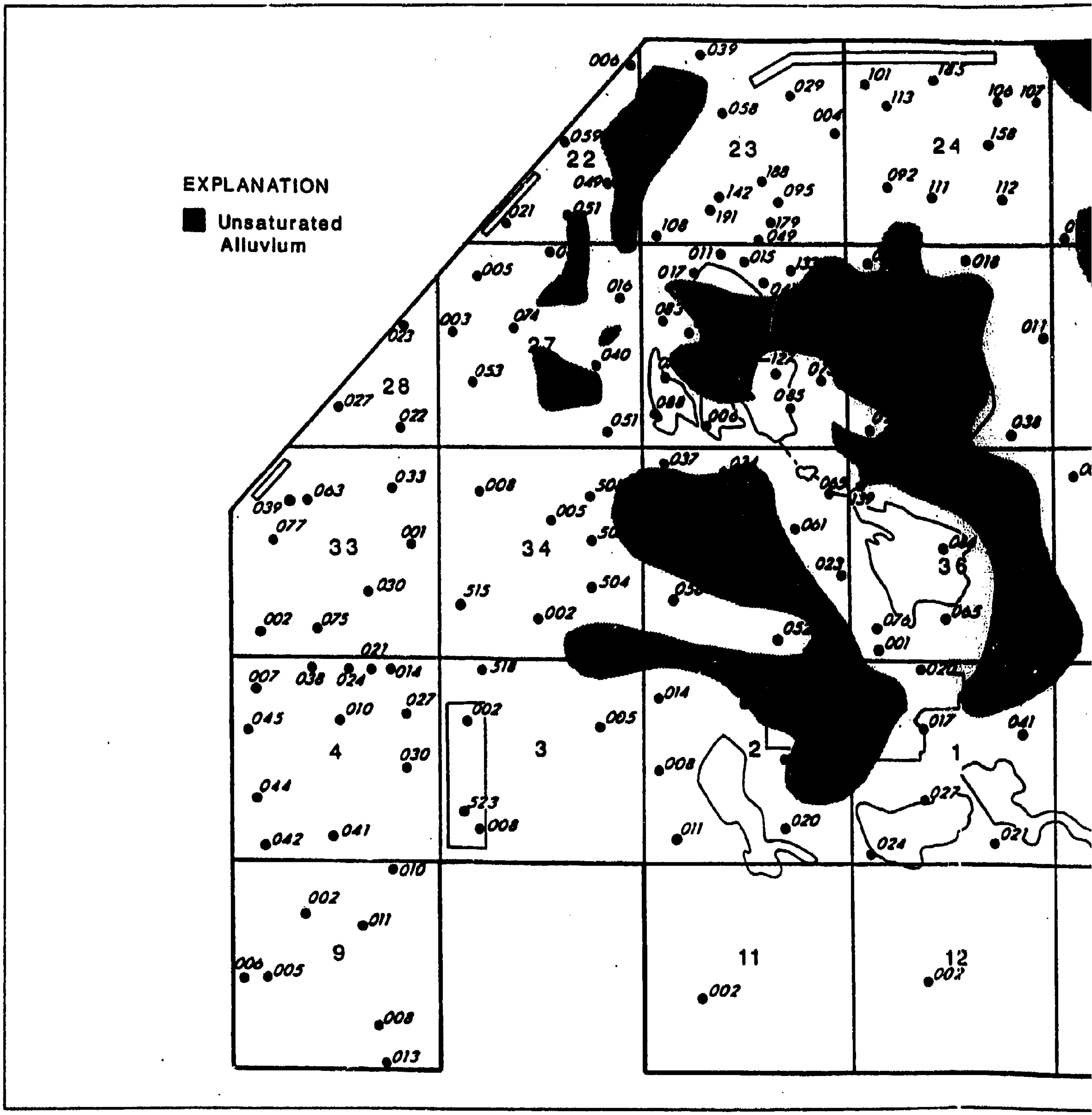
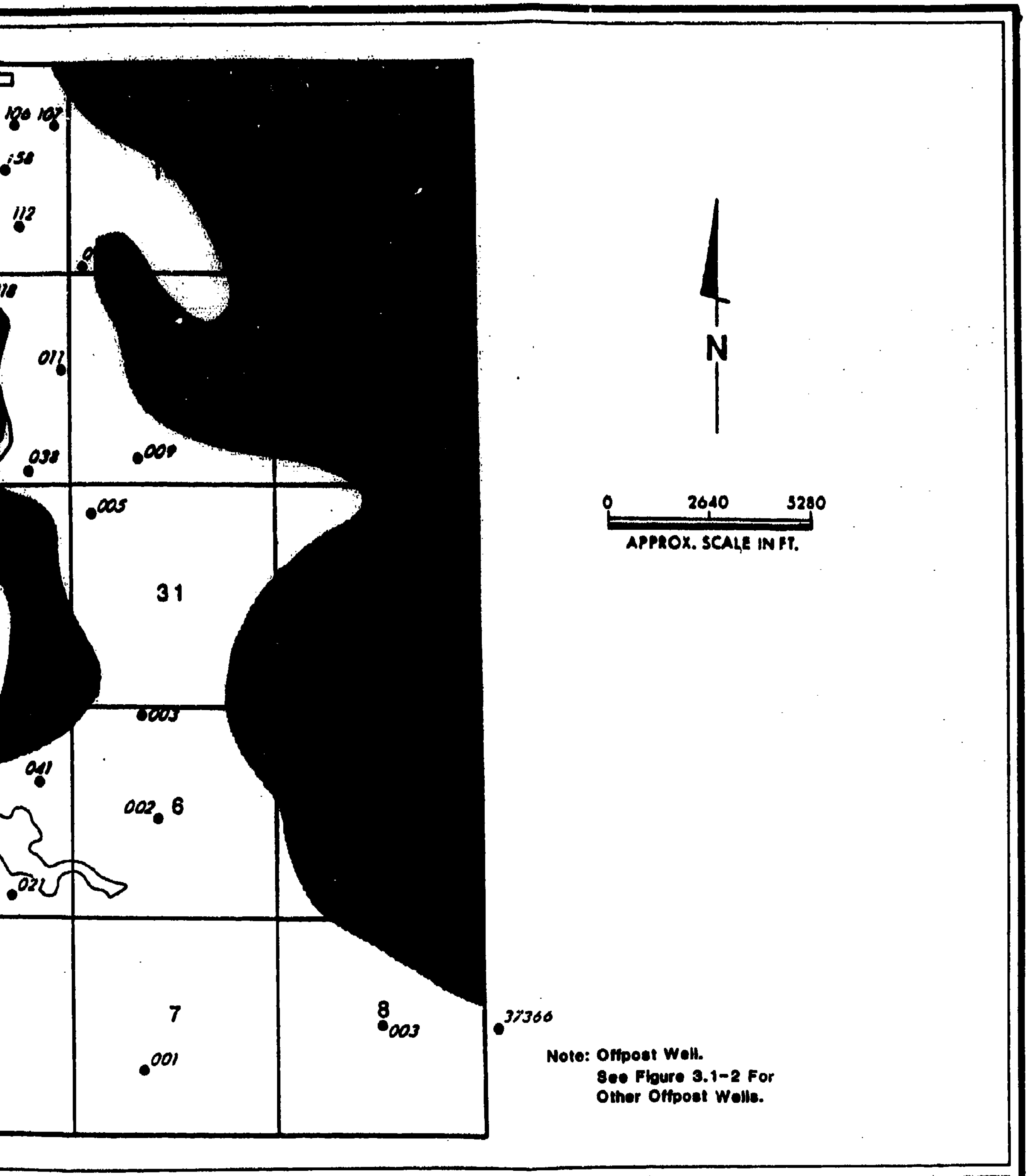


Figure 3.1-5
PROPOSED TASK 44 ONPOST ALLUVIAL MONITORING WELL NETWORK AND U

SOURCE: HLA, 1987



E AND UNSATURATED ALLUVIUM

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Alluvial wells associated directly with five major potential contaminant sites are as follows:

Potential Contaminant Site	Alluvial Wells
South Plants	15
Basin A/A Neck Area	9
Basins B-E	8
Basin F	25
North Plants	5

A total of 27 alluvial wells in Sections 4, 9, and 33 (western tier) are included in the Task 44 program to provide long-term monitoring of the organohalogen and DBCP contamination associated with the Railroad Classification Yard and potential offpost sources.

Paleochannels may, under some conditions, influence directions of ground water flow and provide contaminant migration pathways that facilitate the spread of contamination. Consequently, an effort was made when selecting wells to choose wells that were situated within paleochannels or as close to paleochannels as possible to intersect potential contaminant migration paths. Approximately 42 wells were selected to investigate the importance of paleochannels at RMA (Figure 3.1-6) as related to ground water flow contaminant migration. The paleochannels shown in Figure 3.1-6 were inferred from the Army/ESE and Shell bedrock surface maps. There appears to be a good correlation between paleochannel orientation and alluvial aquifer flow directions. However, in areas where the saturated alluvium thickness exceeds the relative maximum depth of the paleochannels, the influence of paleochannels on ground water flow is reduced and contaminant distribution is thus less controlled by paleotopography.

A set of five wells (06002, 07001, 08003, 11002, and 12002) was chosen to provide regional background monitoring of the alluvial aquifer. These wells also provide a general indication of alluvial water quality flowing onto RMA

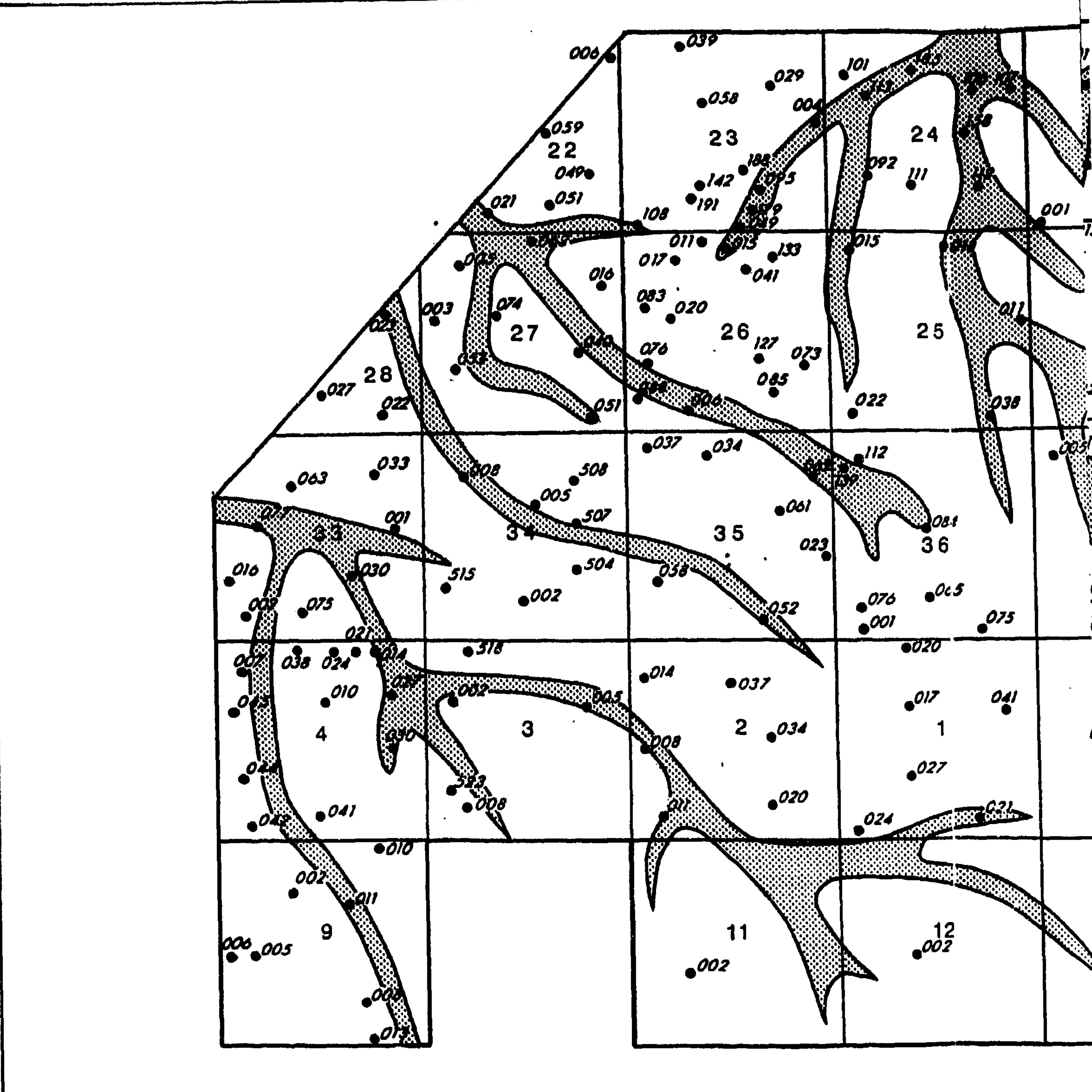
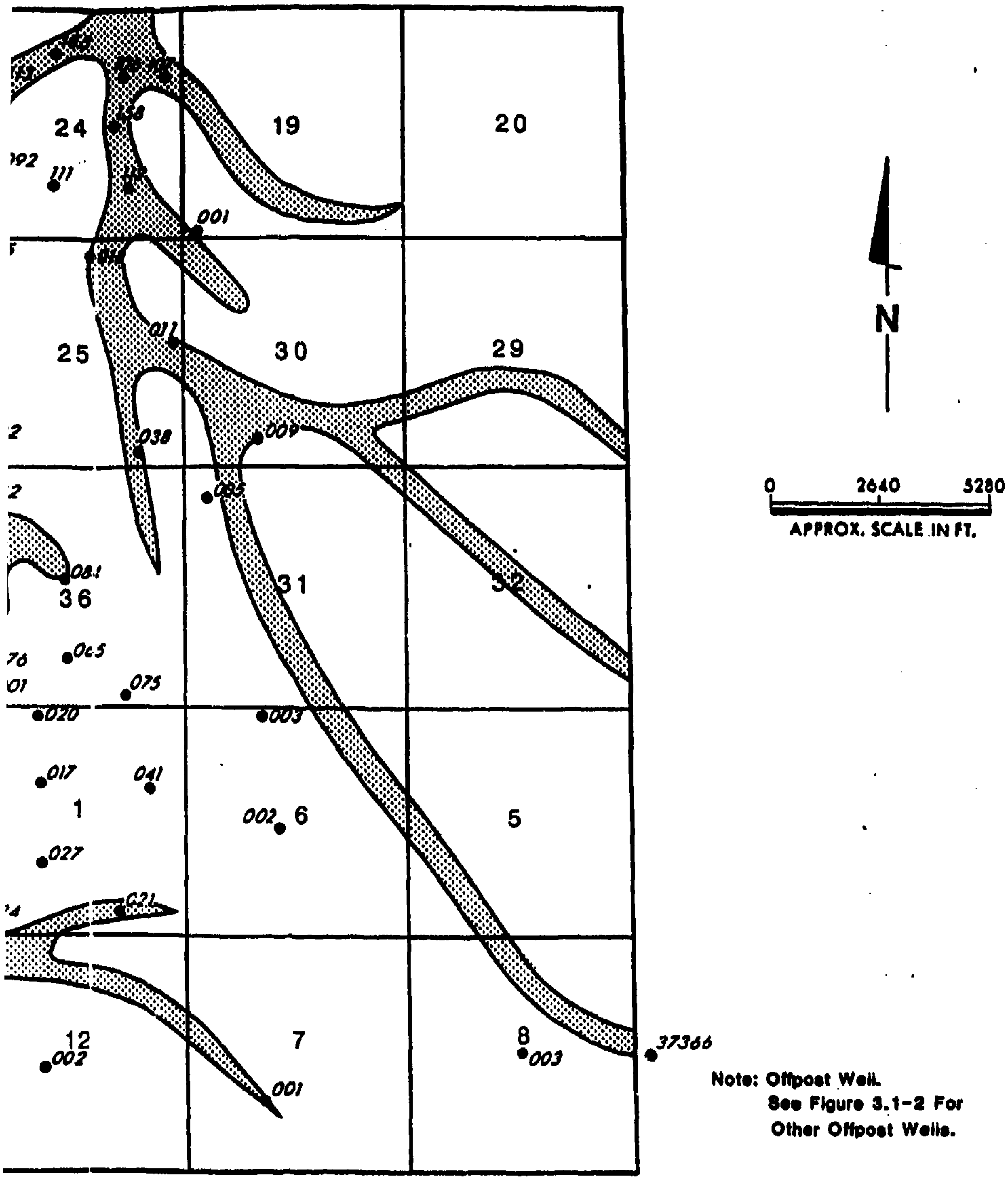


Figure 3.1-6
PROPOSED TASK 44 ONPOST ALLUVIAL MONITORING WELL NETWORK AND INFERRED PALEOCHANNEL LOCATION
SOURCE: ESE, 1987



Note: Offpost Well.
See Figure 3.1-2 For
Other Offpost Wells.

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along the southern tier. A second set of five wells (06003, 19001, 25011, 30009, and 31005) was chosen to monitor the eastern side of RMA and provide contaminant boundary definition.

Denver Formation Well Network

The Denver Formation monitoring well network includes 140 onpost wells chosen from over 500 onpost wells completed in the Denver Formation. The monitoring network is shown in Figure 3.1-4 and individual wells are listed by section in Table 3.1-8. Following examination of Task 4 data, it was determined that the Denver Formation ground water flow and contaminant transport systems were not as well defined as those in the alluvial system. The monitoring network selected includes a larger percentage of Denver wells than were included in the Task 4 network to provide more Denver Formation well data. Additional Denver wells were also selected to provide monitoring in the Denver Formation beneath areas of unsaturated alluvium. Most of the selected Denver Formation wells have been sampled under other RMA tasks within the last year as outlined below:

Current Task 25 wells	10
Task 4 wells	102
Historic wells	28
Total Task 44 Wells	140

The monitoring network attempts to utilizes the best existing Denver Formation wells for both upgradient and downgradient monitoring of potential contaminant sites. Wells associated directly with five major potential contaminant sites are as follows:

Potential Contaminant Site	Denver Wells
South Plants	25
Basin A/A Neck Area	17
Basins B-E	13
Basin F	16
North Plants	10

Eight wells from Sections 4, 9, and 33 (western tier) are also included within the Denver well network to provide long-term monitoring of the organohalogen and DBCP contamination associated with the Railroad

Classification Yard and potential offpost sources. Current information suggests these contaminants are presently restricted to the alluvial aquifer, but monitoring of the Denver aquifer is warranted to ensure that contamination is not spreading or has not spread to the Denver Formation.

A set of five wells (07004, 08005, 11004, 12003, and 12004) were included in the Task 44 network to provide regional background monitoring of the Denver Formation waters in the Southern Tier. These wells also provide a general indication of Denver Formation water quality flowing onto RMA along the southern tier.

A set of eight wells (05001, 06004, 06005, 19003, 19015, 19017, 30011, and 32002) monitor the eastern sections of RMA. These wells provide background information on Denver Formation water quality.

Cluster configurations were given selection preference in the Task 44 network to investigate vertical differences in hydraulic head in the Denver Formation. Table 3.1-9 lists all wells in the Task 44 network that are present in cluster configurations. A further breakdown by section and major aquifer is given in Table 3.1-10. The distribution of well clusters is presented in Figure 3.1-7.

3.1.2.4 Proposed Sampling Schedule

All Task 44 wells will be sampled semiannually and select Task 44 wells will be sampled quarterly. Quarterly samples are scheduled to be collected during the winter, spring, summer, and fall quarters of 1987, and will consist of samples collected from 54 wells in the Offpost and Basin F areas. Specific wells in these area are discussed in Section 3.1.2.2 and 3.1.2.3. Semiannual Task 44 sampling is scheduled to occur in the spring and fall of 1987.

3.1.2.5 Water Level Measurement Network

The network for water level measurements includes most wells from the Task 4 water level network, all Revision III - 360° offpost wells, and additional onpost wells. The current Task 44 water level network consists of about 865 wells for which water levels are measured immediately prior to a sampling event. Approximately 50 of these wells did not yield acceptable

Table 3.1-9. Clustered Wells Incorporated in the Proposed Task 44 Monitoring Network+ (Page 1 of 2)

Section	Clusters
1	(021*, 022), (024*, 025), (041*, 043)
2	(008*, 009, 010), (011*, 012), (020*, 021), (034*, 035, 036), (037*, 038, 039)
3	(002*, 003, 004), (005*, 006)
4	(007*, 008, 009), (010*, 011)
6	(003*, 004, 005)
8	(003*, 005)
9	(002*, 003)
11	(002*, 004)
12	(002*, 003, 004)
22	(021*, 023, 024)
23	(179*, 180, 181), (188*, 189, 190), (191*, 192, 193)
24	(158*, 159)
25	(011*, 013, 014), (015*, 016, 017), (022*, 023), (038*, 039)
26	(073*, 075), (083*, 084), (085*, 086), (127*, 129)
27	(053*, 054, 055)
28	(023*, 026), (027*, 028)
30	(009*, 011)
33	(030*, 032), (033*, 034)

Table 3.1-9. Clustered Wells Incorporated in the Proposed Task 44 Monitoring Network+ (Continued, Page 2 of 2)

Section	Clusters
34	(002*, 003), (005*, 006)
35	(034*, 036), (037*, 038, 039), (052*, 054), (061*, 062, 063), (065*, 066, 067, 068)
36	(065*, 066), (112*, 113, 114)
Off Post	(37343*, 37365)

+ A well cluster is defined as containing at least one alluvial well and one Denver Formation well.

* Alluvial well

Percentage of wells contained in cluster groupings = 36% (111 of 311 wells)

Source: ESE, 1987

Table 3.1-10. Summary of Task 44 Monitoring Wells by Section

Section	Well Total	No. of Clusters+	Alluvial	Denver
1	18	3	6	12
2	20	5	6	14
3	8	2	5	3
4	15	2	12	3
5	1	0	0	1
6	4	1	2	2
7	2	0	1	1
8	2	1	1	1
9	8	1	7	1
11	2	1	1	1
12	3	1	1	2
19	4	0	1	3
20	0	0	-	-
22	11	1	5	6
23	29	3	11	18
24	16	1	9	7
25	13	4	5	8
26	28	4	13	15
27	12	1	8	4
28	5	2	3	2
29	0	0	-	-
30	2	1	1	1
31	1	0	1	0
32	1	0	0	1
33	12	2	8	4
34	10	2	7	3
35	20	5	7	13
36	21	3	7	14
Off Post	43	1	42	1
TOTALS	311	47	170	141

Total alluvial wells as a percentage of Task 44 wells = 55%

+ Clusters are defined as containing at least one alluvial well and one Denver Formation well.

Source: ESE, 1987

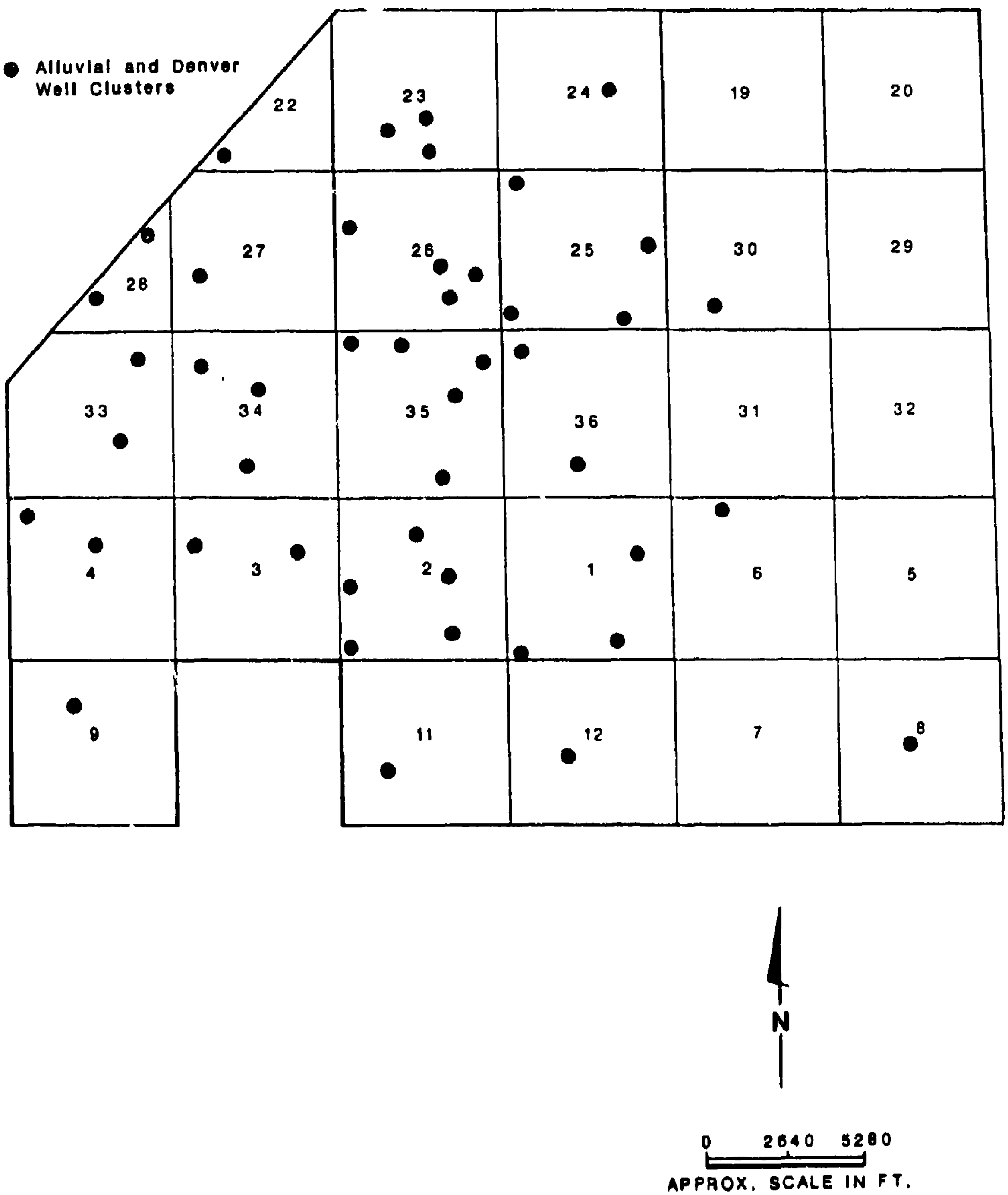

Figure ?.1-7
DISTRIBUTION OF WELL CLUSTERS IN TASK 44

SOURCE: HLA, 1987

Prepared for:
U.S. Army Program Manager's Office For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

measurements because they were found to be dry or obstructed. These wells were deemed unacceptable for water level measurements and removed from the program.

The Task 44 water level measurement program provides continuity of water level data with Task 4 and earlier RMA programs. Wells currently being measured for water levels are listed by section and major aquifer grouping in Tables 3.1-11 and 3.1-12.

3.1.2.6 Comparison of Task 44 with Other Current RMA Ground Water Programs

The recommended ground water monitoring network for Task 44 includes 128 onpost alluvial wells, 140 onpost Denver Formation wells, and 43 offpost monitoring wells. The Task 44 network is the framework for monitoring regional water quantity and water quality. Therefore, other ground water related tasks are superimposed on the Task 44 network. Currently the network includes 25 onpost wells from Task 25 and 11 wells from the Task 38 network (Table 3.1-13). The Task 44 network may be slightly modified based on results from the detailed studies in Tasks 25, 26, 36, 38, and 39. The scope of these other tasks is summarized in Figure 1.2-2 and the area covered by each investigation is shown in Figure 1.2-3.

Task 25 is a detailed hydrogeologic and contaminant distribution program centered on the north and northwest boundary containment systems. The scope of this task includes sampling of approximately 131 wells in Sections 22, 23, 24, and 26 of RMA. Task 26 is a detailed hydrogeological evaluation of the South Plants to Basin A neck area. Approximately 18 alluvial and Denver Formation wells will be installed in Task 26 to enhance the current well distribution and to define hydrogeologic associations and contaminant distributions. Task 36 is a performance evaluation of the NBCS and includes installation of several ground water monitoring wells or piezometers.

The primary objective of Task 38 is to define TCE and DBCP patterns within the alluvial aquifer, and efforts include sampling of 47 wells in RMA Section 3, 4, 9, and 33. Task 38 did not involve any Denver aquifer monitoring.

Table 3.1-11. Well Network for Alluvial Aquifer Water Level Measurements (Page 1 of 2)

Section	Total Wells	Well Numbers
1	28	1, 2, 4, 8, 9, 10, 11, 12, 16, 17, 18, 19, 20, 21, 24, 27, 30, 33, 38, 41, 44, 49, 501, 510, 514, 528, 537, 568
2	16	1, 7, 8, 11, 14, 17, 20, 21, 23, 26, 27, 33, 34, 37, 520, 580
3	13	1, 2, 5, 8, 9, 10, 516, 517, 518, 519, 522, 523, 526
4	41	1, 2, 4, 7, 8, 10, 13, 14, 15, 16, 17, 18, 19, 20, 21, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 35, 36, 37, 38, 39, 40, 41, 42. 44, 45, 524, 525, 527, 528, 529, 532
5	0	None
6	2	2, 3
7	1	1
8	2	2, 3
9	7	1, 2, 5, 6, 7, 8, 13
11	2	2, 3
12	2	1, 2
19	7	1, 3, 4, 5, 6, 7, 8
20	0	None
22	26	3, 4, 5, 6, 8, 12, 14, 16, 17, 18, 19, 20, 21, 22, 25, 29, 45, 49, 50, 51, 52, 53, 54, 56, 59, 60
23	85	2, 4, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 26, 29, 34, 36, 39, 43, 44, 45, 46, 47, 48, 49, 51, 52, 53, 56, 58, 59, 61, 67, 72, 79, 85, 92, 95, 96, 101, 102, 106, 107, 108, 109, 110, 111, 118, 119, 120, 122, 123, 125, 128, 129, 131, 134, 135, 136, 137, 140, 141, 142, 143, 144, 145, 148, 157, 160, 161, 166, 176, 178, 179, 182, 185, 189, 191, 196, 197, 198, 199, 204, 205, 208, 211

Table 3.1-11. Well Network for Alluvial Aquifer Water-Level Measurements (Continued, Page 2 of 2)

Section	Total Wells	Well Numbers
24	60	1, 2, 3, 24, 49, 57, 63, 80, 81, 82, 83, 85, 87, 89, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 103, 105, 106, 107, 108, 110, 111, 112, 113, 114, 115, 117, 121, 122, 123, 126, 127, 128, 135, 150, 158, 161, 162, 163, 164, 166, 169, 170, 178, 179, 180, 181, 182, 184, 185, 188
25	7	8, 11, 15, 18, 22, 35, 38
26	39	2, 4, 5, 9, 11, 15, 16, 17, 18, 19, 20, 24, 26, 40, 41, 44, 47, 48, 50, 62, 63, 65, 68, 70, 71, 73, 74, 76, 78, 81, 83, 85, 88, 91, 93, 124, 127, 133, 145
27	51	2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 15, 16, 17, 19, 25, 28, 30, 32, 34, 37, 40, 41, 42, 43, 44, 45, 40, 51, 53, 56, 59, 62, 63, 64, 66, 68, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83
28	22	2, 3, 5, 6, 7, 8, 9, 11, 12, 14, 15, 18, 20, 21, 22, 23, 24, 27, 28, 30, 503, 513
29	1	2
30	3	4, 6, 9,
31	6	2, 3, 5, 6, 9, 10
32	1	
33	63	1, 2, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 30, 33, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 54, 57, 58, 59, 60, 61, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 75, 77, 500, 501, 502, 505, 506, 507, 509, 510, 511, 512, 514, 531, 533, 534, 576, 577, 579, 580
34	4	2, 5, 8, 515
35	22	5, 6, 7, 14, 18, 23, 25, 26, 30, 31, 34, 37, 40, 47, 48, 52, 53, 58, 61, 65, 66, 69
36	48	1, 10, 13, 17, 24, 29, 43, 54, 56, 60, 63, 65, 67, 68, 69, 73, 74, 75, 76, 77, 81, 82, 84, 85, 86, 87 89, 90, 91, 92, 93, 99, 103, 112, 123, 128, 134, 135, 136, 137, 138, 139, 140, 141, 142, 145, 146

Total: 560 plus 42 off-post alluvial wells = 602 Total

Source: ESE, 1987

Table 3.1-12. Well Network for Denver Aquifer Water Level Measurements (Page 1 of 2)

Section	Total Wells	Well Numbers
1	28	7, 14, 15, 22, 23, 25, 28, 29, 31, 32, 34, 35, 36, 37, 39, 40, 43, 45, 46, 47, 48, 50, 518, 522, 534, 554, 586, 588
2	28	5, 9, 10, 12, 13, 15, 16, 18, 19, 22, 24, 25, 28, 30, 31, 32, 35, 36, 38, 39, 43, 44, 45, 46, 545, 578, 583, 585
3	4	3, 4, 6, 7
4	3	9, 11, 12
5	3	1, 2, 3
6	2	4, 5
7	2	4, 5
8	2	4, 5
9	2	3, 4
11	1	4
12	2	3, 4
19	7	2, 11, 15, 16, 17, 18, 19
20	0	None
22	7	2, 23, 24, 27, 28, 30, 31
23	15	54, 177, 180, 181, 183, 184, 186, 187, 190, 192, 193, 200, 201, 209, 210
24	13	86, 109, 120, 124, 125, 136, 159, 167, 168, 171, 172, 174, 175
25	23	4, 7, 9, 10, 12, 13, 14, 16, 17, 19, 20, 21, 23, 24, 25, 26, 29, 31, 34, 36, 37, 39, 40

Table 3.1-12. Well Network for Denver Aquifer Water Level Measurements (Page 1 of 2)

Section	Total Wells	Well Numbers
26	34	27, 28, 43, 52, 58, 60, 61, 64, 66, 67, 69, 72, 75, 80, 82, 84, 86, 89, 90, 92, 94, 96, 97, 123, 128, 129, 130, 134, 135, 140, 141, 142, 146, 147
27	6	49, 54, 55, 57, 58, 59
28	3	25, 26, 29
29	1	3
30	5	5, 7, 8, 10, 11
31	3	7, 8, 11
32	2	2, 3
33	8	26, 27, 28, 29, 31, 32, 34, 35
34	6	3, 4, 6, 7, 9, 10
35	31	8, 9, 12, 13, 15, 16, 17, 24, 27, 28, 32, 33, 35, 56, 38, 39, 41, 50, 51, 54, 55, 56, 59, 62, 63, 67, 68, 70, 71, 73, 74
36	21	36, 57, 61, 62, 66, 72, 78, 79, 83, 104, 105, 110, 113, 114, 116, 117, 118, 119, 121, 122, 147

Total: 262 plus 1 off-post Denver Formation well = 263

Table 3.1-13. Wells Incorporated in the Proposed Task 44 Network From Other Current RMA Monitoring Programs

Task 25 Wells (25)

Denver	Alluvial
22023, 22031, 23181, 23184, 23189, 23209, 23210, 24086, 24120, 24124	22006, 22049, 22051, 23004, 23029, 23039, 23058, 24092, 24101, 24106, 24111, 24113, 24185, 27003, 27074

Task 38 Wells (11)

Denver	Alluvial
None	04038, 04041, 04042, 04044, 04045, 09008, 09010, 09011, 09013, 33075, 33077

Source: ESE, 1987

Additional monitoring wells that were constructed and sampled following completion of Task 4 will be included in the Task 44 network. Seventeen of the 47 wells from the more detailed Task 38 program have been included in Task 44.

Task 39 is the offpost RI/FS task. This program involves well installation in areas where data is essential to FS efforts. Data generated from these wells will be useful to both Tasks 25 and 44.

The total number of wells (311) in Task 44 is very similar to the 317 total number of wells in the Task 4 Initial Screening Program (ISP). The main difference between these programs is that Task 44 includes 43 offpost wells generally located north and northwest of RMA.

Additionally, Task 44 well coverage is designed to provide contaminant pattern definition without overemphasizing areas of consistently high or low values. Therefore, the areal coverage is more uniform than found in the Task 4 ISP.

3.1.3 PROPOSED LONG-TERM MONITORING NETWORK

The Task 44 network will provide the basis for a long-term monitoring network. The selection of wells for inclusion in Task 44 was based on the evaluations discussed earlier. The wells have subsequently been grouped into central contaminant, western contaminant, and background areas labeled Regions 1, 2, and 3, respectively, in Figure 3.1-8. RMA was subdivided in this manner to identify areas where the suite of target analytes can be reduced or modified. A characteristics summary for each Task 44 well by region is presented in Tables 3.1-14 through 3.1-16. The long-term monitoring program will be selected from these wells and will also include newly installed wells. The long-term monitoring network selection may be conducted using Task 44 selection criteria. Decisions will also be based on field observations and analytical results from initial Task 44 sampling.

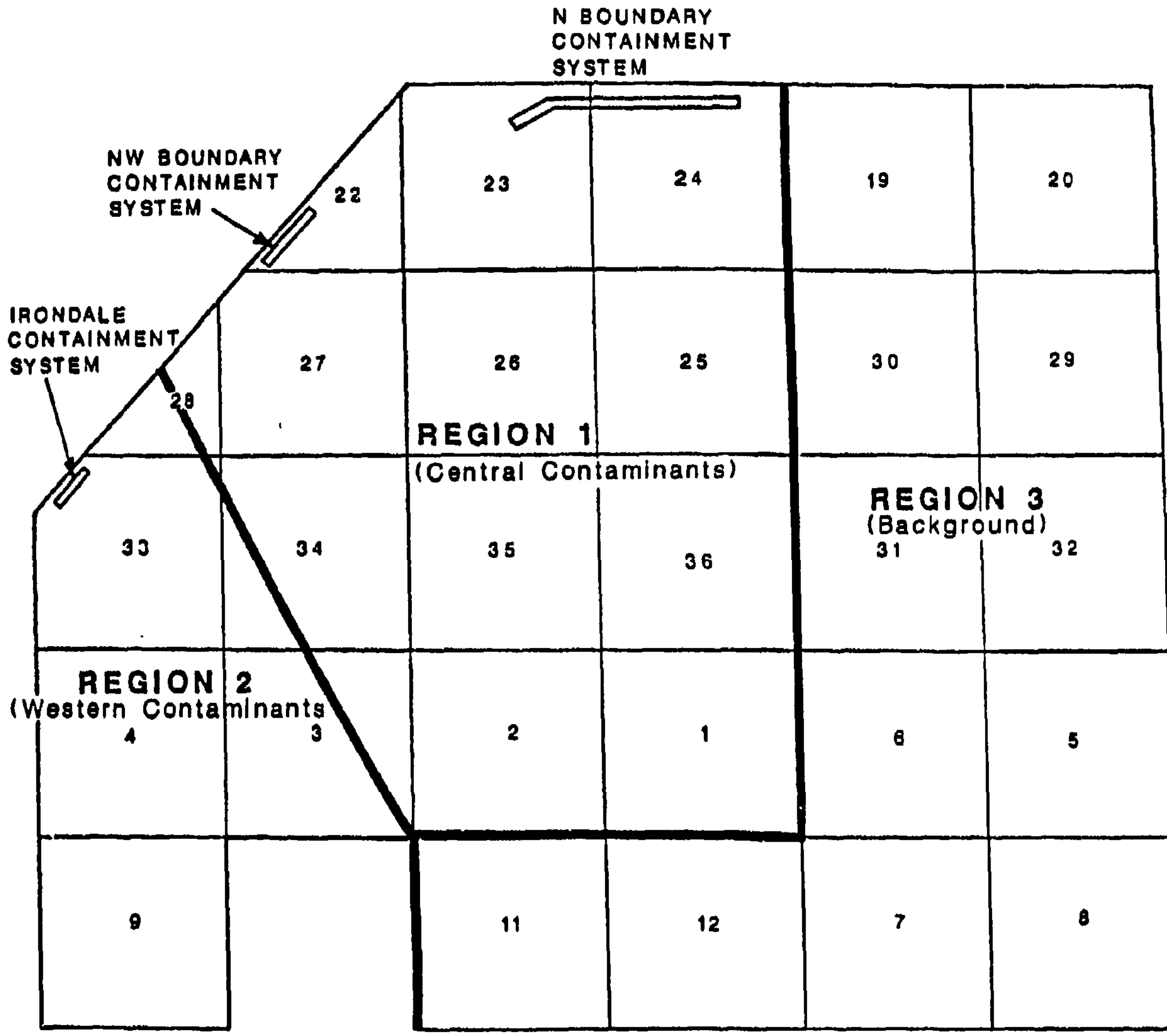

Figure 3.1-8
MAJOR REGIONS OF WATER QUALITY AT RMA

SOURCE: HLA, 1987

Prepared for:
U.S. Army Program Manager's Office For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

Table 3.1-14. Region 1 - Central Contaminant Patterns (N = 240, 77% of all Task 44 Wells) (Page 1 of 8)

Well No.	Aquifer	Consistent Chemical Results	Well Location Relative to Task 4 Alluvial Contamination Patterns: Central	Boundary	Background	Well Sample Cluster	No. of Sample Rounds Tasks 4	25	Well Construction Ranking	Comments
01007	D	N	X				0	0	2	Historically DBCP, CHPSO
01008	D	N	X				1	0	2	Historically CHCl3, TRCLE, Dieldrin, As
01012	D	Y	X				3	0	2	TCA, dieldrin, CPMSO2, CHCl3
01015	D	Y					0	0	2	Historically DBCP (0.52)
01017	A	N	X				1	0	2	Clean ISP; historically CPMSO2 = 40, DIMP = 2 & 853; DBCP; DITH
01020	A	Y	X				3	0	2	Volatiles, DBCP, OXAT, DITH, Organo Sulfurs, Metals
01021	A	Y			X	X	3	0	4	Clean
01022	D	Y			X	X	3	0	4	Clean
01024	A	Y			X	X	3	0	4	Clean
01025	D	Y			X	X	3	0	4	Clean
01027	A	N			X		1	0	4	Clean; historically isodrin, benzene
01036	D	Y	X				0	0	3	Historically DBCP
01037	D	Y	X				0	0	3	Historically DBCP and benzene
01041	A	N	X			X	0	0	3	Historically DBCP, benzene and aldrin
01043	D	Y	X			X	0	0	3	Clean
01047	D	Y		X			0	0	3	Clean
01048	D	Y		X			0	0	3	Clean
01050	D	Y		X			0	0	3	Clean
02008	DP	N		X		X	3	0	2	CHPSO2, ClC6H5
02009	D	Y		X		X	3	0	4	Clean
02010	D	Y		X		X	3	0	4	Clean
02011	AP	Y			X	X	2	0	4	Clean
02012	D	Y			X	X	2	0	4	Clean
02014	A	N		X			0	0	3	Historically dieldrin, CHCl3, benzene, DCPD
02016	D	Y		X		X	1	0	4	Clean; historically unconfirmed aldrin
02019	D	N		X			3	0	4	Toluene, As, benzene
02020	A	N			X	X	3	0	4	Pesticides, volatiles, As
02021	D	Y		X		X	0	0	4	Historically clean
02025	D	N	X				0	0	4	Historically benzene, chloroform
02030	D	Y	X				3	0	4	Chloroform ~ 100
02031	D	Y	X				3	0	4	Clean
02034	A	Y	X			X	3	0	3	Volatiles, pesticides
02035	D	Y	X			X	3	0	3	Volatiles Hg, As
02036	D	Y	X			X	3	0	3	Clean
02037	A	Y	X			X	3	0	2	Chloroform, dieldrin
02038	D	Y	X			X	3	0	3	Chloroform ~ 8, low level dieldrin
02039	D	Y	X			X	3	0	3	Clean
02043	D	Y	X				0	0	3	Historically chloroform ~4

Table 3.1-14. Region 1 - Central Contaminant Patterns (N = 240, 77% of all Task 44 Wells) (Continued, Page 2 of 8)

Well No.	Aquifer	Consistent Chemical Results	Well Location Relative to Task 4 Alluvial Contamination Patterns: Central	Boundary	Background	Well Sample Cluster	No. of Sample Rounds Tasks 4	25	Well Construction Ranking	Comments
03005	A	N			X	X	3	0	4	Pesticides, DCFD
03006	D	Y			X	X	1	0	4	As; historically clean
22006	A	Y-N		X			0	2	2	Current Task 25; well historically inconsistent DBCP and pesticides consistent DIMP 4-100
22021	AP	N	X			X	3	1	3	Chloroform ~10, inconsistent As, Hg; historically pesticides
22023	D	Y	X			X	1	2	4	Clean in ISP; historically clean; current Task 25 well
22024	D	N	X			X	3	1	4	DCFD and DIMP in ISP, clean in later rounds
22027	D	N	X				1	0	4	Benzene in ISP; historically clean
22028	D	N	X				1	0	4	Clean in ISP; historically inconsistent aldrin
22030	D	N		X			1	0	4	As in ISP; historically inconsistent dieldrin
22031	D	N		X			1	2	4	ISP clean; benzene, CPMSO in Task 25; historically benzene
22049	A	Y		X			0	0	4	Current Task 25 well; historically DIMP ~40
22051	AP	N		X			0	2	2	Task 25 well historically inconsistent pesticides, DBCP ~3 DIMP ~12
22059	A	N		X			3	1	3	Consistent chloroform ~10, inconsistent dieldrin and DBCP
23004	A	Y	X				0	2	2	Task 25 pesticides, DCPD, DBCP, DIMP organosulfurs, OXAT, DITH, volatiles historically inconsistent CPMSO pesticides, consistent DITH, DIMP, DBCP, DCPD, CPMA, CPMSO2
23029	A	Y	X				1	2	2	Task 25 volatiles, pesticides, DIMP, organosulfurs
23039	A	N		X			0	2	2	Historically inconsistent isodrin, DIMP
23049	AP	Y-N	X				0	0	2	Dry twice in Task 4; historically inconsistent DBCP, CPMS; consistent CPMSO2, DIMP, Endrin, DITH
23053	D	N		X			0	0	2	Historically CPMSO2, DBCP, DCPD, DIMP, DITH, pesticides
23054	D	N	X				0	0	2	Historically CPMS, CPMSO2, DCPD, DITH, pesticides
23058	A	N		X			0	1	2	Task 25 DIMP, DCE, CHCl3; historically DIMP, possibly dieldrin
23095	AP	Y	X				3	0	1	DCPD ~500, DIMP ~1100, OXAT, DITH, volatiles, pesticides
23100	A	Y		X			3	0	1	Clean; historically DIMP 100-200 in 1978, clean 1982-1985

Table 3.1-14. Region 1 - Central Contaminant Patterns (N = 240, 77% of all Task 44 Wells) (Continued, Page 3 of 8)

Well No.	Aquifer	Consistent Chemical Results	Well Location Relative to Task 4 Alluvial Contamination Patterns: Central	Boundary	Background	Well Sample Cluster	No. of Sample Rounds Tasks 4.	25	Well Construction Ranking	Comments
23142	A	N		x			3	0	2	DIMP 100-1000, OXAT, DITH; historically DIMP
23161	D	Y	x				0	2	3	Task 25 clean; historically clean, behind north boundary slurry wall 3.2 DIMP 1979
23177	D	Y	x				3	1	4	DIMP, DCPD, DCLE; in front of north boundary slurry wall
23179	AP	Y	x			x	3	1	4	DBCP, DCPD, DIMP ~800 OXAT, DITH, volatiles
23180	D	N	x			x	3	0	4	Benzene, DMDS
23181	D	N	x			x	1	2	4	DIMP, CPMSO2; BDL in Task 25
23182	D	N		x			3	1	4	As, chloroform; Task 25 chloroform
23183	D	N		x			3	1	4	As, benzene; Task 25 clean
23184	D	Y		x			1	2	4	As in ISP, Task 25 inconsistent pesticides
23185	D	Y		x			3	1	4	DIMP ~4500, DITH, OXAT, As as in one round; Task 25 DIMP, OXAT, DITH
23186	D	N		x			3	1	4	DIMP, As, Benzene; Task 25 benzene
23187	D	N		x			3	1	4	No confirmed hits, clean
23188	AP	Y	x			x	3	1	4	DCPD, DIMP ~1000, OXAT, DITH, volatiles, As, pesticides; Task 25, dieldrin, DCPD, OXAT, DITH, CPMSO2
23189	D	N	x			x	3	2	4	DIMP; Task 25 clean
23190	D	Y	x			x	3	1	4	No confirmed hits
23191	A	Y	x			x	3	1	4	DIMP ~700, OXAT, DITH, dieldrin
23192	D	N	x			x	3	1	4	Inconsistent low level As otherwise clean; Task 25 benzene
23193	D	N	x			x	1	0	4	Aromatics
23209	D	N	x				0	2	2	TCE, aromatics; Task 25 one benzene
23210	D	N	x				1	1	2	Aromatics; historically clean, pump lodged in well; Task 25 clean
24086	D	Y		x			0	2	2	Task 25, DIMP 28, unconfirmed CPMSO; historically clean
24089	D	N		x			0	0	2	Historically DBCP, DIMP ~70 downgradient GB Plant
24092	AP	Y		x			0	1	2	Task 25 DIMP 80; historically DIMP, dieldrin
24101	AP	N	x				0	0	2	Current Task 25 well; historically CPMSO, DBCP, DIMP, dieldrin, endrin
24106	A	Y		x			0	2	2	Task 25, a pesticide and organo sulfur hit; historically clean
24107	AP	Y			x		0	1	2	Task 25 clean; historically clean
24111	AP	Y		x			0	2	2	Task 25 one dieldrin hit, DIMP ~160; historically DIMP 100-300
24112	AP	Y			x		0	0	2	Historically clean

Table 3.1-14. Region 1 - Central Contaminant Patterns (N = 240, 77% of all Task 44 Wells) (Continued, Page 4 of 8)

Well No.	Aquifer	Consistent Chemical Results	Well Location Relative to Task 4 Alluvial Contamination Patterns: Central	Boundary	Background	Well Sample Cluster	No. of Sample Rounds Tasks 4	25	Well Construction Ranking	Comments
24113	AP	Y	X				0	1	2	Task 25 DIMP 20; historically DIMP 20-600
24120	D	Y		X			0	1	-	Task 25, dieldrin, documented as destroyed; historically clean
24124	D	Y		X			0	2	2	Task 25, historically clean, possible DBCP
24127	D	N	X				1	1	2	Task 25, pesticides, DCPD, DBCP, DIMP, CPMS, CPMSO2, TCLEE
24130	D	Y	X				0	0	2	Historically 40 DIMP, 25 DBCP unconfirmd DCPD 660
24158	AP	Y		X		X	3	1	3	Clean; Task 25 clean
24159	D	Y		X		X	3	1	4	Clean; Task 25 clean
24185	AP	Y	X				2	1	3	Task 4 clean; one unconfirmed dieldrin and CPMSO hit in Task 25
25009	D	N		X			3	0	4	Unconfirmed pesticide, Hg and benzene
25011	AP	Y			X	X	3	0	4	Clean
25013	D	Y			X	X	3	0	4	Clean, one unconfirmed aldrin hit in ISP
25014	D	Y			X	X	3	0	4	Clean, one unconfirmed aldrin and dieldrin hit in ISP
25015	A	Y		X		X	3	0	4	Clean
25016	D	Y		X		X	3	0	4	Two benzene hits
25017	D	Y		X		X	1	0	4	Clean; historically clean
25018	A	Y		X			0	0	4	Historically DIMP 300, north of SB Plant
25021	D	Y		X			0	0	3	Historically chlorobenzene, DBCP, DCPD
25022	A	Y		X		X	3	0	3	Clean, one unconfirmed benzene
25023	D	N		X		X	3	0	3	Clean, unconfirmed CPMS in ISP, unconfirmed benzene
25038	A	Y			X	X	1	0	3	Clean
25039	D	Y			X	X	1	0	3	Clean
26006	AP	Y	X						1	Pesticides inconsistent CPMS, CPMSO2, DBCP, DCPD, DIMP 1000-4000, DITH
26011	A	Y	X				3	0	2	Pesticides, DIMP, OXAT, DITH, organosulfurs, As
26015	AP	Y	X				3	0	1	OXAT, DITH, DIMP, As, CPMSO2, CPMS
25017	A	Y	X				3	0	1	DIMP, OXAT, DITH, dieldrin, CPMSO
26019	D	Y	X				0	0	2	DIMP
26020	A	N	X				3	0	1	DIMP ~1000, DITH, TRICLE, CHCL3, dieldrin
26041	A	Y	X				3	0	2	DCLE, TRCLE, pesticides inconsistent, aromatics, Hg, As, DCPD, DMMP, DIMP 3000, DMDS, OXAT, DITH, organosulfurs

Table 3.1-14. Region 1 - Central Contaminant Patterns (N = 240, 77% of all Task 44 Wells) (Continued, Page 5 of 8)

Well No.	Aquifer	Consistent Chemical Results	Well Location Relative to Task 4 Alluvial Contamination Patterns: Central	Boundary	Background	Well Sample Cluster	No. of Sample Rounds Tasks 4	25	Well Construction Ranking	Comments
26041	A	Y	x				3	0	2	DCLE, TRCLE, pesticides, aromatics, Hg, As, DCPD, DIMP ~3000, DMMP, DMDS, OXAT, DITH, organosulfurs
26057	D	N	x				0	0	2	DIMP, pesticides
26058	D	N	x				0	0	2	DIMP, DITH, endrin
26061	D	N	x				0	0	2	CPMSO, CPMSO2, DIMP 2700, DITH
26066	D	Y	x				3	0	2	Benzene, DIMP, OXAT, DITH, TRCLE, TCLEE, chlorobenzene, CPMS
26067	D	N	x				1	0	2	Unconfirmed dieldrin; historically DIMP
26071	D	Y	x				1	0	2	Pesticides, Hg, As, DIMP 5000, OXAT, DITH, organo-sulfurs, TCLEE, chlorobenze
26072	D	Y	x				0	0	2	Historically DIMP ~40
26073	A	Y		x		x	3	0	1	Chloroform, CCl4, dieldrin
26075	D	Y		x		x	1	0	2	Clean except for low dieldrin: Historically clean
26076	A	Y	x				1	0	2	Historically DIMP ~700, possible pesticides
26083	A	N	x			x	3	0	2	As, one DIMP 19
26084	D	N	x			x	3	0	2	Low level dieldrin, As, CPMSO, CPMSO2
26085	A	Y	x			x	3	0	2	DBCP, DIMP, TRCLE, chloroform, unconfirmed pesticide; Hg, As
26086	D	N	x			x	3	0	2	DIMP, DITP, As, chlorobenzene, pesticides
26088	AP	N		x			0	0	2	DIMP, dieldrin
26127	A	Y	x			x	3	0	2	DIMP 1900, OXAT, DITH, CPMS, CPMSO, CPMSO2
26129	D	N	x			x	1	0	2	Pesticides, As, CPMS, CPMSO, CPMSO2, unconfirmed CHCl3; chlorobenzene
26133	AP	Y	x				3	0	2	Chloroform, CH2Cl2, pesticides, aromatics, Hg, As
26140	D	N	x				3	0	3	DIMP, pesticides, CHCl3, benzene, Hg
26142	D	N	x				3	0	3	Aldrin, dieldrin; historically dieldrin
26147	D	Y	x				3	0	4	Clean; historically clean
27003	A	Y		x			1	2	2	Clean; Task 25 inconfirmed dieldrin
27005	A	Y		x			0	1	2	Task 25 clean
27016	A	Y		x			2	1	1	DIMP ~400, dieldrin inconsistent
27040	AP	Y	x				3	1	2	DBCP, DIMP, DCLE, TRCLE, CHCl3, dieldrin, As
27049	D	N		x			0	1	2	Historically DIMP ~80 Task 25 CHCl3 20
27051	A	Y		x			0	0	2	Historically clean
27053	AP	Y		x		x	3	1	4	Clean; Task 25 clean
27054	D	Y		x		x	1	1	4	Trace aromatics; Task 25 trace aromatics

Table 3.1-14. Region 1 - Central Contaminant Patterns (N = 240, 77% of all Task 44 Wells) (Continued, Page 6 of 8)

Well No.	Aquifer	Consistent Chemical Results	Well Location Relative to Task 4 Alluvial Contamination Patterns: Central	Boundary	Background	Well Sample Cluster	No. of Sample Rounds Tasks 4	25	Well Construction Ranking	Comments
27055	D	N		x		x	3	1	4	Organohalogen; Task 25 no hits; basically clean
27057	D	N	x				3	1	4	One hit chlorobenzene: Task 25 clean
27062	A	Y	x				3	1	4	Dieldrin, DBCP, DIMP, CPMSO2, DCLE, TRCLE, As; Task 25 well
27074	A	Y		x			1	2	4	CHCl3, dieldrin; Task 25 well
28023	A				x	x	3	1	2	Clean
28026	D	Y			x	x	3	1	3	One aromatic hit; clean; Task 25
clean										
34002	A	Y		x		x	3	0	4	Clean
34003	D	Y		x		x	1	0	4	Clean
34005	A	Y		x		x	1	0	4	Dieldrin, CHCl3 at 44; historically DCPD
34006	D	Y		x		x	1	0	4	As; historically clean
34008	AP	Y		x			3	0	4	Clean, one dieldrin hit
34009	D	Y		x			3	0	4	One DMDS hit; historically clean
34504	A	—		x			0	0	?	Never sampled before, paleochannel?
34507	AP	—		x			0	0	?	Never sampled before, paleochannel?
34508	A	—		x			0	0	?	Never sampled before, paleochannel?
35013	D	N	x				3	0	2	DIMP 2000, TSP, BDL rounds 3 and 4; organohalogens
35016	D			x			1	0	2	DIMP 3300, DITH, TRCLE, As, chlorobenzene; historically DIMP 600-4600
35017	D			x			1	0	2	Historically clean
35023	A		x				0	0	2	Historically CHCl3, CPMSO, benzene, DBCP, DIMP, TCLEE
35034	A	Y		x		x	2	0	2	CHCl3, dieldrin, DIMP, As
35036	D	Y		x		x	1	0	2	Historically clean
35037	A	Y		x		x	3	0	2	CHCl3, dieldrin, aldrin
35038	D	N		x		x	3	0	2	Benzene hit twice, dieldrin once
35039	D	N		x		x	2	0	2	As hit once, unconfirmed dieldrin
35052	A	N		x		x	3	0	4	Sporadic As, DCE
35054	D	Y		x		x	1	0	4	As; historically clean
35056	D	Y		x			1	0	4	Clean; historically clean
35058	A	Y		x			3	0	4	CHCl3, dieldrin, arsenic
35061	A	Y		x		x	3	0	4	Clean
35062	D	Y		x		x	3	0	4	As twice, otherwise clean
35063	D	Y		x		x	3	0	4	Organosulfur unconfirmed, otherwise clean
35065	AP	Y	x			x	3	0	4	TRCLE, TCLEE, DIMP 2000, OXAT, DITH, pesticides, DCPD, organosulfurs
35066	D	Y	x			x	1	0	4	Similar data to 35065

Table 3.1-14. Region 1 - Central Contaminant Patterns (N = 240, 77% of all Task 44 Wells) (Continued, Page 7 of 8)

Well No.	Aquifer	Consistent Chemical Results	Well Location Relative to Task 4 Alluvial Contamination Patterns: Central	Boundary	Background	Well Sample Cluster	No. of Sample Rounds Tasks 4	25	Well Construction Ranking	Comments
35067	D	Y	X			X	3	0	4	Clean except for one As
35068	D	Y	X			X	3	0	4	DIMP in ISF only clean
36001	A	Y	X				3	0	4	Very high values for many analytes
36056	D	Y	X				0	0	2	Historically high values for CPMSO2, DIMP, DITH, OXAT, dieldrin
36065	AP	Y	X			X	3	0	2	TRCLE, CHCl3, CCL4, DBCP, As, benzene
36066	D	Y	X			X	3	0	2	Sporadic trace, CHCl3, benzene
36069	D	Y		X			1	0	2	DCLE, otherwise clean; historically clean
36075	A			X			3	0	2	Clean
36076	A	Y	X				3	0	2	High volatiles; DBCP, MIBK, OXAT, Dith, As, organosulfurs
36083	D	Y	X				3	0	2	As, one dieldrin hit, otherwise clean
36084	A	Y	X				1	0	2	Many analytes with high concentrations
36090	D	Y		X			1	0	2	Volatiles, DITH, OXAT, organosulfurs, As, benzene, ETC6H5
36110	D	Y	X				3	0	2	As, low level dieldrin
36112	A	Y	X			X	3	0	3	DIMP 1400, OXAT, DITH, DCLE, TCLEE, CHCl3, pesticides, As
36113	D	Y	X			X	3	0	3	One hit DCLE, otherwise clean
36114	D	Y	X			X	3	0	4	One hit As, otherwise clean
36116	D	N		X			0	0	4	Dry ISF; historically sporadic CHCl3 and endrin
36117	D	Y		X			1	0	3	Clean ISF; historically sporadic endrin
36119	D	Y		X			1	0	3	Clean; historically clean
36121	D	Y		X			3	0	4	Clean; historically clean, possibly CHCL3 or benzene
36122	D			X			1	0	3	Clean; historically clean, possibly CHCl3 or benzene
36139	AP		X				3	0	3	DIMP 200-300, OXAT, DITH, CPMS CMPSO2, DCLE, CHCl3, As
36154	D	—		X			0	0	4	Never sampled under any task
Off-Post Wells										
37305	A	N	X				2	0		Aldrin, As
37307	A	Y	X				3	0		As, DCPD, DBCP, DIMP 40-200
37308	A	Y	X				3	0		TCLEE, DCPD, DBCP, DIMP 300-500, dieldrin, CPMSO, CHCL3, DCLE

Table 3.1-14. **Region 1 - Central Contaminant Patterns (N = 240, 77% of all Task 44 Wells)**
(Continued, Page 8 of 8)

Well No.	Aquifer	Consistent Chemical Results	Well Location Relative to Task 4 Alluvial Contamination Patterns: Central	Boundary	Background	Well Sample Cluster	No. of Sample Rounds Tasks 4	25	Well Construction Ranking	Comments
37309	A	Y	x				3	0		CFMSO, CFMSO2, aromatics, DCLE, TRCLE, TCLEE, As, DCPD, DBCP, DIMP ~1000, aldrin, DDE, OXAT, DITH
37312	A	Y	x				3	0		DIMP 30, dieldrin, endrin
37313	A	N	x				3	0		As, DIMP 5000, OXAT, DITH CFMSO, CFMSO2
37320	A	Y		x			3	0		As DIMP 30-120
37332	A	Y	x				3	0		As, DIMP, DBCP, DIMP ~11, dieldrin
37333	A	N					3	0		As, dieldrin, benzene, CHCl3
37335	AP	N		x			3	0		As, dieldrin
37338	AP	N	x				3	0		As, DIMP ~11, CHCl3
37339	A	Y	x				3	0		As, DIMP 70-270
37340	A	Y		x			3	0		As, DIMP 30
37341	A	N		x			3	0		As, DIMP ~15
37342	A	N	x				3	0		DIMP ~50, aldrin, TCLEE
37343	A	N	x			x	3	0		DIMP 90-1100, CHCl3
37344	A	Y		x			3	0		As, DBCP, DIMP 40-1500, CFMSP, CHCl3 CCL4, TCLEE, TRCLE
37345	A	Y	x				3	0		As
37346	A	Y	x				3	0		As
37347	A	Y	x				3	0		DIMP ~40
37348	A	Y	x				3	0		Clean
37349	A	Y	x				3	0		DIMP ~150
37350	A	N		x			3	0		Benzene
37351	A	Y	x				3	0		DIMP ~16
37352	A	Y	x				3	0		As
37353	A	Y	x				3	0		DIMP ~200
37354	A	Y		x			3	0		DIMP 14, CHCl3, TCLEE
37355	A	Y	x				3	0		CHCL3, TCE
37356	A	N	x				3	0		As, DIMP ~200
37357	A	Y	x				3	0		DIMP 40, CHCl3, TCLEE
37360	A	Y		x			3	0		Clean
37361	A	Y		x			3	0		DDE
37362	A	Y	x				3	0		Clean. DIMP 15, CHCl3
37363	A	Y		x			3	0		Clean
37364	A	Y		x			3	0		Clean except for one As value
37365	D	N	x			x	3	0		DIMP 19, benzene
Boller	A	Y		x			3	0		DBCP, DIMP 140, CFMSO, CHCl3, TRCLE, TCLEE
XII	A	N		x			3	0		TRCLE
XXI	A	N	x				3	0		DIMP 40, DITH

Table 3.1-15. **Region 2 - Western Tier Contaminant Patterns (N = 48, 16% of all Task 44 Wells) (Page 1 of 2)**

Well No.	Aquifer	Consistent Chemical Results	Well Location Relative to Task 4 Alluvial Contamination Patterns: Central	Boundary	Background	Well Sample Cluster	No. of Sample Rounds Tasks 4	38	Well Construction Ranking	Comments
03002	A	Y		x		x	2	0	4	Clean
03003	D	N		x		x	2	0	4	Basically clean, inconsistent hits, benzene at 8
03004	D	Y		x		x	2	0	4	CHCl3, paleochannel area
03078	A	Y		x			3	1	4	Clean; Task 38 clean
03518	A	Y		x			0	0	3	No historical sampling
03523	A	Y	x				3	1	3	DBCP 40-50, CHCl3; Task 38 CHCl3, DBCP, benzene
04007	AP	Y	x			x	3	2	4	DCE, TRCLE, TCLEE; Task 38 same compounds
04008	D	Y	x			x	1	0	4	Clean except for trace aldrin; historically clean
04009	D	Y	x			x	0	0	4	Historically CHCl3, otherwise clean
04010	A	Y		x		x	3	1	4	Clean; Task 38 clean
04011	D	Y		x		x	0	0	4	Historically clean; Task 38 one benzene hit
04014	AP	Y	x				3	1	2	DBCP 6-14; Task 38 DBCP at 15
04021	AP	Y	x				0	2	2	Historically DBCP is BDL; Task 38 TRCLE, CHCl3, TCE
04024	A	Y	x				3	1	2	Clean; Task 38 one benzene hit
04027	AP	Y	x				3	1	4	DBCP 30-40; Task 38, DBCP 31
04030	A	Y	x				3	4	2	DCE, TRCLE 200, CHCl3; Task 38, DCLE, TCE, CCl4 TRCLE 200, benzene
04038	A	Y		x			0	3	4	Task 38, DCE, TCE, TRCLE; new well
04041	A	Y		x			0	4	4	Task 38, DCE, TCE, TRCLE, trace benzene, CHCl2
04042	AP	Y		x			0	2	4	Task 38, DCE, TRCLE, TCLEE
04044	AP	Y		x			0	2	4	Task 38, DCE, CHCl3, TCE, TRCLE, TCLEE, chlorobenzene
04045	AP	Y		x			0	2	4	Task 38, DCE CHCl3, TRCLE, TCLEE
09002	AP	Y		x		x	3	2	4	TCLEE; Task 38, TCE, TCLEE
09003	D	Y		x		x	0	1	4	Task 38, clean; historically clean
09005	AP	Y	x				3	1	2	DCE, TRCLE, TCLEE; Task 38, DCE, TRCLE, TCLEE
09006	A	Y	x				1	0	2	Clean; no historic sampling
09008	A	Y			x		0	2	4	Task 38, DCE, TCE, TRCLE
09010	A	Y			x		0	1	4	Task 38, clean
09011	A	Y		x			0	2	4	Task 38, DCE, TCE, TRCLE
09013	AP	Y			x		0	1	4	Task 38, DCE, DCLE, CHCl3, TCE, TRCLE, TCLEE
28022	A	Y		x			0	0	2	Historically clean
28027	A	Y		x		x	3	1	2	TCE; Task 38 TCE, benzene
28028	D	Y		x		x	1	0	4	Clean; historically clean

Table 3.1-15. Region 2 - Western Tier Contaminant Patterns (N = 48, 16% of all Task 44 Wells) (Continued, Page 2 of 2)

Well No.	Aquifer	Consistent Chemical Results	Well Location Relative to Task 4 Alluvial Contamination Patterns: Central	Boundary	Background	Well Sample Cluster	No. of Sample Rounds Tasks 4	38	Well Construction Ranking	Comments
33001	AP	Y		x			0	0	2	Historically clean abundant data, rare DIMP, pesticide hits
33002	AP	N	x				3	2	2	TRCLE, DCE, TCLEE; Task 38, 2 rounds, DCE, TCE, TRCLE
33016	D	Y		x			3	0	2	Clean; Task 38, 2 rounds, benzene hits
33026	D	Y	x				0	1	4	Task 38, clean; historically minor CHCl3
33030	AP	Y		x		x	3	1	4	DBCP, CHCl3; Task 38, DBCP
33032	D	Y		x		x	0	1	4	Historically clean; Task 38, benzene
33033	A	Y		x		x	2	0	4	Clean
33034	D	Y		x		x	0	1	4	Historically clean; Task 38, benzene
33039	A	Y	x				0	0	2	Historically DBCP ??
33063	A	Y	x				1	0	3	DBCP, aldrin; historically DBCP, no analysis for aldrin
33075	A	Y	x				0	0	2	Task 38, DCE, TCE, TRCLE, and one benzene hit
33077	AP	Y	x				0	3	2	Task 38, TCE, TRCLE
34515	A	Y		x			0	1	3	Task 38, clean; no historical data
Region 2 Off-Post Wells										
37358	A	Y		x			3	0	-	One DMMP hit otherwise clean
37359	A	Y		x			3	0	-	One TCE hit, 3 TRCLE and TCLEE hits
C111	A	Y		x			3	0	-	One CPMS and one TCE hit, TRCLE,

Table 3.1-16. Region 3 - Background (N = 23, 7% of all Task 44 Wells) (Page 1 of 2)

Well No.	Aquifer	Consistent Chemical Results	Well Location Relative to Task 4 Alluvial Contamination Patterns: Central	Boundary	Background	Well Sample Cluster	No. of Sample Rounds Task 4	Well Construction Ranking	Comments
05001	D	Y			X		1	1	Clean; historically clean
06002	A	Y			X		3	2	Clean
06003	A	Y			X	X	3	4	Clean
06004	D	Y			X	X	3	4	Clean
06005	D	Y			X	X	3	4	One minor DBCP hit
07001	A	Y			X		3	2	Clean
07004	D	Y			X		3	4	Clean
08003	AP	Y			X	X	1	4	One minor endrin hit, historically clean
08005	D	Y			X	X	1	4	Clean; historically clean, one minor benzene hit
11002	AP	Y			X	X	3	4	Clean
11004	D	Y			X	X	3	4	Clean
12002	A	Y			X	X	3	4	Clean
12003	D	Y			X	X	3	4	One benzene hit; historically clean
12004	D	Y			X	X	3	4	One DBCP hit
19001	AP	N			X		0	2	Historically inconsistent DIMP
19003	D	Y			X		0	2	Historically clean, possible pesticide hit
19015	D	Y			X		3	4	Clean; historically clean, one benzene hit
19017	D	Y			X		1	4	Clean; historically clean
30009	AP	Y			X	X	0	4	Historically clean
30011	D	Y			X	X	0	4	Historically clean
31005	A	Y			X		1	4	Clean; historically clean
32002	D	Y			X		1	4	Clean, low level edrin; historically clean
37366	AP	Y			X		3	-	One DIMP hit, one benzene hit

ICLEE

Table 3.1-16. Region 3 - Background (Page 2 of 2)

Explanation key for Task 44 Monitoring Well Network.

Well No. = Section number (2 digits) followed by 3 digit well number. Well numbers ≥500 are SCC wells.

Aquifer = A = alluvial, D = Denver Fm aquifer. Designation is based on the top of screen relative to bedrock. Wells with the top of screen below the bedrock surface are classified as Denver Fm wells. AP = alluvial well within or immediately adjacent to an inferred or projected paleochannel.

Consistent Chemical Results = Y = yes, N = no. Based on the overall trend, may vary for individual compounds. For example, DIMP values are often consistent whereas pesticide values are generally erratic.

Well Location Relative to Task 4 Alluvial Contamination Patterns = Relative position of well location to contaminant patterns, as a whole, for the alluvial aquifer. The areal extent of Denver Fm patterns was not considered for this ranking. Well locations within approximately 1500 ft of a contaminant pattern boundary are generally classified as boundary wells. Background wells are wells located further than 1500 ft from the contaminant patterns and/or upgradient of contaminant patterns. Central wells are those wells located within contaminant patterns and away from the borders or boundaries of such patterns.

Well Sample Cluster = An X indicates the well is within a well sample cluster. A well cluster is defined as a closely grouped series of wells with at least one well screened in the alluvial aquifer and one well totally screened in the Denver Fm. Well groups screened within the alluvium or within the Denver Fm are not considered clusters for the purpose of this report.

No. of Sampling Rounds = Number of times a well has been sampled under Tasks 4, 25, or 38.

Well Construction Ranking = Construction ranking where 1 = unacceptable, 2 = questionable, 3 = potentially acceptable, and 4 = acceptable well construction. The ranking is a measure of the amount and quality of well construction information. A ranking of 2 (questionable) does not indicate questionable chemical results, only that the construction information was insufficient to assign a higher ranking.

Comments = Listing of compounds or elements detected in past sampling events. Historical data listed when one or less round of data was available for Task 4, 25, or 38. Compound abbreviations are standard USATHAMA abbreviations. All values are in ppb (ug/L) unless noted otherwise.

N = Number of wells in a region followed by the percent of the total Task 44 wells in that specific region.

3.2 GROUND WATER MONITORING PROCEDURES

3.2.1 INTRODUCTION

The management structure for coordination of onsite field personnel performing ground water monitoring activities will include an onsite field supervisor, two support technicians, a safety officer, and 5 to 6 two-person field teams. One member of each field team will be designated as the field team leader and will be responsible for all tasks completed by his/her team. Field team leaders will be selected from personnel who have a minimum of 6 months previous sampling experience at RMA. The daily activities of all field teams will be managed by an onsite field supervisor. In addition, the field supervisor will review all data collected, ensure that chain-of-custody records are maintained, and supervise sample collection, handling, packaging, and shipment.

At the beginning of each monitoring program, field team leaders will be issued field kits containing field instruments, sampling equipment, calibration standards, and operator's manuals, as well as copies of the Technical Plan, sampling plan, QA plan, and the RMA Section Plots and Well Summary Report (D.P. Associates, 1985, RIC#85183R01). These kits will include a submersible pump, a stainless steel bailer system (including 1 ft threaded bailer sections and a Teflon bottom-decanting device), a compressor and/or generator, and a 4-ft x 2-ft x 2-ft metal storage locker. Each locker will be equipped with the following:

1. pH, conductivity and dissolved oxygen meters as well as a complete set of spare probes, cables, and batteries for each instrument and a flow thru cell in which to take measurements.
2. Digital alkalinity titration kits.
3. Calibration standard solutions and detailed calibration procedure instructions.
4. Two 100-ml wash bottles and a set of: two 500-ml, two 250-ml, and two 100-ml beakers.
5. A water level measuring device.
6. 300 ft nylon-clad steel tape.
7. A roll of plastic sheeting.

8. 100 spare gloves.
9. 50 plastic bags.
10. 1,000 ft of 1/4 in nylon rope.
11. Metals filtration kit (peristaltic pump, filter holder, replacement hoses, filters, 50 ml of dilute nitric acid, and pH indicator paper).
12. A complete set of spare sample fraction containers.
13. A detailed sample procedure plan taped in plastic to the inside lid of the locker.
14. Well volume calculation chart for 1-in to 8-in wells.
15. 1:1 sulfuric acid for nitrate preservation.

Each field kit will be restocked as necessary by the field team leader following each day of sampling. Additional field equipment (deionized water, 55 gallon barrels, decontamination wash basins) will be stocked as needed by each field team. At least one complete set of spare field instruments will be kept readily available at the onsite support facility.

Prior to the start of field work, the onsite supervisor will ensure that all personnel have been fully trained in the operation of all field equipment and that each team member understands the field procedures described in the task technical plan. In the event that procedure modifications are made or additional equipment or instrumentation is incorporated into an ongoing program, the field supervisor will schedule training sessions introducing these modifications or equipment changes to the field personnel as well as providing written instructions.

All data collected during a ground water monitoring program will be recorded on pre-printed field data sheets and in bound field logbooks. When not in use, all field logbooks will be maintained by the field supervisor and kept in a secured area at the site support facility. Logbooks will be checked out by the field supervisor to the field team leaders on a daily basis. Examples of the preprinted field data sheets used for water level measurement, sample collection, logbook checkout, and chain-of-custody are presented in Figures 3.2-1 through 3.2-4. A complete discussion of chain-of-custody procedures may be found in Section 3.2.6 of this document.

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RECORD OF ACTIVITIES AT WELL SITES
WATER LEVEL MEASUREMENTS

PROJECT ______________________________ PROJECT NUMBER ________________

LOCATION ______________________________ SUPERVISOR ________________

Well No.	Casing Dia. (In.)	Date	Time	PID Reading		Stick Up		Water Level		Total Depth (Feet)	Measuring Device	Sampler Initials	Comments
				Bkgnd	TOC	(Feet)	(Tenths)	(Feet)	(Tenths)				

Figure 3.2-1
RECORD OF ACTIVITIES AT WELL SITES-
WATER LEVEL MEASUREMENTS

SOURCE: HLA, 1987

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

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RECORD OF ACTIVITIES AT WELL SITE
FIELD SAMPLING DATA SHEET

Page ______ of ______

Well Number ______ Location ______ Date ______

Project ______ Project No. ______ Samplers ______

Station Elevation ______ Well Stick Up ______ Supervisor ______

Well Depth ______ Casing Diameter ______ Water Level (From TOC) ______

Gallon Water/Ft. ______ Casing Volume ______ Screened Interval ______

PID Readings (Bkgrnd) ______ TOC ______

FIELD CHEMISTRY

Calibration: Time ______ pH 7.00 - ______ at ______ °C pH 10.00 - ______ at ______ °C
Conductance: Standard ______ umhos/cm at 25 °C Reading ______ umhos/cm at ______ °C
D.O. Meter: ______ mg/l at ______ °C

Condition of Well ______

Time	Pumping Rate gpm	D.O. mg/l	pH	Temp. °C	E.C umhos/cm at °C	Cum. Vol. of H_2O Removed gallons	Casing Vols.	PID Reading Loc.	Value	Comments

Remarks: ______

FIELD EQUIPMENT

pH meter ______ Serial No. ______

E.C. meter ______ Serial No. ______

Pump ______ Serial No. ______

Water Level Meter ______ Serial No. ______

D.O. Meter ______ Serial No. ______

Filter Apparatus ______ Filters ______

Temperature Measure ______

Bailer ______ Size ______

SAMPLING DESCRIPTION:

Fractions: V V V V W W DB DC NF C S GCMS Dup.

No. of Bottles ______

Sample Depth ______

Field Notebook No. ______

Sample Method ______

Discharge H_2O Containerized ____Yes ____No.

Figure 3.2-2
FIELD SAMPLING DATA SHEET

SOURCE: HLA, 1987

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
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FIELD NOTEBOOK CHECK OUT / CHECK IN

PROJECT ______________________ PROJECT NUMBER ______________________

LOCATION ______________________ SUPERVISOR ______________________

NOTEBOOK NUMBER	CHECK OUT			CHECK IN		
	DATE	TIME	INITIAL	DATE	TIME	INITIAL

Figure 3.2-3
FIELD NOTEBOOK SIGN-OUT SHEET

SOURCE: HLA, 1987

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

ENVIRONMENTAL SCIENCE & ENGINEERING 04-15-87 *** FIELD LOGSHEET *** FIELD GROUP: T44NW3
PROJECT NUMBER 87436 0000 PROJECT NAME: RMA TASK44 LAB COORD. HUGH PRENTICE
T44NW3

ESE #	SITE/STA	HAZ?	FRACTIONS(CIRCLE)	DATE	TIME	PARAMETER LIST	SAM TYPE	SITE TYPE	DEPTH CM	S TECH	INSTAL SAMPLE
*1	01007		C S NF V V V V			T44Q3					
*2	01015		C S NF V V V V			T44Q3					
*3	01036		C S NF V V V V			T44Q3					
*4	01037		C S NF V V V V			T44Q3					
*5	01041		C S NF V V V V			T44Q3					
*6	01043		C S NF V V V V			T44Q3					
*7	01047		C S NF V V V V			T44Q3					
*8	01048		C S NF V V V V			T44Q3					
*9	01050		C S NF V V V V			T44Q3					
*10	02014		C S NF V V V V			T44Q3					
*11	02021		C S NF V V V V			T44Q3					
*12	02043		C S NF V V V V			T44Q3					
*13	22049		C S NF V V V V			T44Q3					
*14	23039		C S NF V V V V			T44Q3					
*15	23053		C S NF V V V V			T44Q3					
*16	24089		C S NF V V V V			T44Q3					
*17	24101		C S NF V V V V			T44Q3					
*18	24112		C S NF V V V V			T44Q3					
*19	24130		C S NF V V V V			T44Q3					
*20	25018		C S NF V V V V			T44Q3					

NOTE -CHANGE OR ENTER SITE ID AS NECESSARY; UP TO 9 ALPHANUMERIC CHARACTERS MAY BE USED
-CIRCLE FRACTIONS COLLECTED. ENTER DATE, TIME, FIELD DATA (IF REQUIRED), HAZARD CODE AND NOTES
-HAZARD CODES: I-IGNITABLE C-CORROSIVE R-REACTIVE T-TOXIC WASTE H-OTHER ACUTE HAZARD; IDENTIFY SPECIFICS IF KNOWN
-PLEASE RETURN LOGSHEETS WITH SAMPLES TO ESE

RELINQUISHED BY: (NAME/ORGANIZATION/DATE/TIME)	RECEIVED BY (NAME/ORGANIZATION/DATE/TIME)
1	
2	
3	

OTHER FIELD NOTES FOR FIELD GROUP T44NW3:

Figure 3.2-4
USATHAMA TASK 44 CHAIN-OF-CUSTODY LOGSHEET

SOURCE: HLA, 1987

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

3.2.2 WATER LEVEL MEASUREMENT PROCEDURES

Water level measurement programs will be conducted prior to the initiation of each water sampling event. A sufficient number of field teams will be mobilized to ensure that all water level data is collected in a timely manner (i.e., approximately one week assuming approximately 900 well measurements). The procedure for collecting water level measurement data is summarized below:

1. With a respirator on, approach the well from an upwind direction.
2. Zero the pre-calibrated photoionization detector (PID) to ambient air conditions.
3. Remove the well cap and take an immediate PID reading of the headspace at the top of the casing (TOC), followed by a PID reading of the breathing zone area. Record these readings. All notations are recorded in duplicate on the water level measurement form (Figure 3.2-1) and in a bound field logbook.
4. Record the well number, date, time, and initials of field personnel taking measurements.
5. Measure the length of the riser stickup from the ground surface to a measuring point marked at the TOC and record the length to the nearest one-tenth foot. Measure and record casing diameter in inches.
6. Insert the water level indicator probe until it reaches water. Measure the depth to water from the same measuring point at the TOC and record the value to the nearest one-tenth foot.
7. Measure the total depth of the well in the same fashion.
8. Retrieve the water level indicator probe and rinse the cable and probe with deionized water as they are withdrawn from the well.
9. Record the make and model of the water-level indicator used.
10. Compare total depths, water level, and stickup to previous measurements (where applicable) and values listed in the RMA Well Summary Report (D.P. Associates, 1985, RIC#85183R01). If discrepancies are observed, second measurement verifications will be performed and documented as such.
11. Record well conditions (cracked casing, missing cap, subsidence features, etc.) and any other pertinent observations.

12. Insure that all labels and flagging clearly indicate the well's location and the well number.
13. Police the area to assure that all equipment and materials have been retrieved, no litter is left, and the well cap is secure.

3.2.3 GROUND WATER SAMPLING PROCEDURES, CONTAINERS, AND PRESERVATION

The onsite field supervisor will prepare a daily schedule of field activities and will provide each field team leader with a prepared sample kit. Each kit will be composed of a sample cooler containing sample containers, labels, chain-of-custody forms, ice, and a well information file. The well file will include previous and historical water level data, expected casing volume, and any comments generated during the preceding water level measurement phase and prior sampling events. Field team leaders will ensure that sample and field kits are complete and that all instruments and sampling equipment are in good working condition.

On arriving at the well site, the following procedures will be implemented:

1. With respirators on and from an upwind direction, uncap well and record background and casing headspace readings with a photoionization detector (PID) as described previously for water level measurements. Respirators may be removed if PID values are at background levels within the breathing zone around the well head.
2. Record well number, date, pertinent observations (e.g., weather, well condition) station elevation, casing diameter, screened interval and field instrument identification.
3. Record well stickup, depth to water, and total well depth. All measurements will be made from a measuring point marked at the top of casing (TOC). Compare measured values with previous measurements; investigate and document any discrepancies. All equipment used downhole to obtain water level and total depth measurements will be decontaminated with deionized water (D.I. rinse).
4. Calculate and record casing volume; compare with previous volumes to ensure relative compatibility.

5. Calibrate field instruments against known standards. Record instrument calibration responses, times, and calibration standards used. Field instrumentation is used to monitor the following parameters: pH, temperature, conductivity, alkalinity, and dissolved oxygen (pumped wells only).
6. The decision to pump or bail a well will be made based on the relative efficiency of either method with respect to the amount of purge water to be removed. In general, wells containing less than 4 gallons/casing volume or known to dewater at 1 casing volume will be purged and sampled by bailing. All other wells will be pumped.
7. All wells will be purged and sampled from the top of the water column. Bailers will be slowly lowered into the water column to a depth equal to the length of the bailer being used. Pumps will be placed 2 to 3 ft below the top of the water column and repositioned as necessary in response to water level fluctuations during evacuation. An in-line flow cell consisting of an air-tight chamber fitted for instrument probes will be used on all pumped wells. In addition, the field parameter list described in Item 5 above will include dissolved oxygen measurements for all pumped wells.
8. A portion of the initial water discharged from the well will be collected and the following information recorded: field parameter values (pH, temperature, conductivity, and dissolved oxygen), time, PID reading, pumping rate, and purged volume removed. Similarly, this information will be documented after each casing volume is removed. All purged water will be containerized at the well site.
9. A minimum of five casing volumes will be removed from each well prior to sampling. However, samples will not be collected until field parameters have stabilized from three consecutive casing volumes. Wells which dewater prior to the removal of five casing volumes or stabilization will be exempt from these requirements. Samples will be collected from these wells once sufficient recharge has been attained. Dewatered wells will be given a maximum of 24 hours to recharge. If sufficient recharge has not

been attained within a 24-hour period, as many sample fractions as possible will be collected.

10. An alkalinity titration will be performed on a portion of the well water obtained after the fifth or final casing volume has been removed. Titration volumes required to reach colorimetric end points will be recorded along with associated pH values (taken coincidently).

11. Sample parameters will also be measured and recorded immediately prior to sample collection. Sample labels will be completed to include the following information: well number, time, data, temperature (°C), conductivity, pH, sampler's initials, and dissolved oxygen (for pumped wells only).

12. When pumps are being used, samples will be collected directly from pump discharge lines at low flow rates to avoid agitating samples and possibly degassing of volatiles. If bailed, samples will be collected from bottom decanting bailers.

13. Sample bottles will be rinsed with well water prior to filling. Sample fractions will be filled in the following sequence: (1) VOA (three 40-ml amber bottles); (2) DBCP and DCPD (one each 250-ml amber bottles); (3) organosulfur and organochlorine compounds (two 1,000-ml amber bottles); (4) chloride/fluoride (1,000-ml clear plastic cubitainer); (5) metals (two 1,000-ml clear plastic cubitainers); (6) nitrates (1,000-ml clear plastic cubitainer). The VOA, DBCP and DCPD sample fractions will be filled completely and capped tightly to avoid air bubbles. In addition, VOA fractions will be placed in a can and the can lid secured. Except for metals, all remaining sample fractions are filled to a minimum of 90 percent capacity. Metal fractions will be filtered in the field using 0.45 micron nitrocellulose or cellulose acetate filters, until each cubitainer is filled to a minimum of 700 ml, and preserved with dilute nitric acid to a pH of ≤ 2. Unfiltered nitrate fractions will be preserved with sulfuric acid to a pH of ≤ 2. All sample fractions will be placed on ice immediately upon filling. Sampling technique, sample depth, and fractions collected will be recorded on the sample data sheet, chain-of-custody record, and in the field logbook.

14. The field team leader will sign and date the sample data sheet after ensuring that the sheet has been fully completed and the information has also been recorded in the field logbook. The field team leader will complete the chain-of-custody record when relinquishing the samples.
15. All sampling equipment will be thoroughly decontaminated (deconned) at the well site prior to storage. Except for pumps, all equipment will be cleaned in a solution of COR-approved water and trisodium phosphate, rinsed with COR-approved water and triple-rinsed with deionized water. All external pump parts will be triple-rinsed with deionized water. In order to decontamination the inside of the pump, a volume of deionized water equal to three times the volume of the pump and hoses will be pumped through the line. All decontamination water will be containerized at the well site. All cleaned equipment will be wrapped and stored in clean plastic sheeting.
16. Each barrel used to containerize well and decontamination water will be sealed and labeled with an appropriate inventory number, task number, date, job number, contractor(s) name, well number and nature of contents (ground water).
17. The final activity at the well site will be to remove all sampling equipment and debris from the area.

In addition to the above listed procedures, the following guidelines will be used to mitigate any potential problems that could adversely affect sample integrity:

1. Avoid agitation of VOA samples collected from either pumps or bailers. This will reduce air stripping of volatiles and allow for the collection of more representative samples.
2. Sampling equipment including pumps, hoses, bailers, rope, etc., should contact only the well or a clean plastic surface. Equipment should never contact the ground or any other surface which has the potential to transmit contaminants. This equipment should always be encased or wrapped in clean plastic during transport.

3. Change gloves frequently when handling downhole instruments. Always change gloves after working on compressors or other equipment prior to sampling. New gloves will be worn at the start of well purging and changed immediately prior to sample collection.
4. When working on downhole equipment (bailers, pumps, etc.) either decontaminate tools prior to use or decontaminate the equipment before re-entering the well.
5. Avoid splashing water or dirt on plastic ground cloths. Replace ground cloth if it becomes dirty.
6. Vent gasoline engines downwind at least 30 ft from the well head. Gas tanks should be filled before going to the field. Keep all sampling equipment away from potential gasoline spills or leaks.
7. Replace dropped bottles, lids, or septa with spares from the kit. Avoid contact with edges or inside surfaces of sample bottles.
8. Ensure that septa and Teflon cap liners are in good condition. Check that septa are oriented with Teflon side down. Once full, septa bottles should be transported upside down.
9. Avoid sampling when precipitation or windblown dust may contaminate the sample.
10. Do not dip pH indicator paper into samples, check by pouring a small amount of sample over the paper.
11. To avoid unnecessary agitation of the water column, bailers will be lowered slowly into the well. A knot tied in the bailing rope approximately 2 ft above the static water level will serve as a marker below which the bailer will be lowered very slowly.
12. Ensure that a stainless steel protector is emplaced over the well head prior to bailing. This protector will prevent the bailing rope from cutting into the top edge of the PVC casing.
13. When reassembling the filter head assembly, the 0.45 micron filter must be handled with stainless steel tweezers.
14. Sample bottles will be filled from a pump discharge line located upstream of the flow cell.

15. When sharp increases are observed in dissolved oxygen readings, a bailer will be used in place of the pump to sample the well. Pumps will only aerate samples when they are malfunctioning and should be repaired. Pumped samples are generally cleaner and preferable to bailed samples.

3.2.4 CHAIN-OF-CUSTODY

Chain-of-custody forms will be issued with corresponding sample kits by the Field Team Coordinator. Each sample will be accompanied by two separate chain-of-custody forms; one form for sample fractions sent to ESE-Gainesville and one for fractions analyzed at ESE-Denver (Figure 3.2-4). These forms are an inventory of the samples and of those persons with access to the samples. They will be transported with the samples at all times. Possession of the samples will begin with the sample collectors. All subsequent sample transfers will require the relinquisher and the receiver to sign, date, and record the time of transfer on the chain-of-custody forms.

Data on the chain-of-custody forms will be checked by the Field Team Coordinator and will include the sample number, collection date and time, fractions collected, measured pH and conductivity values, sample depth, well stick-up, and location and value of the highest encountered PID reading. The Field Team Coordinator will obtain this data from the Field Sampling Data Sheets transmitted by the sampling teams.

3.2.5 SAMPLE SHIPMENT

By the end of each sampling day all samples will have been trought back to the sample handling trailer for packaging. The Field Team Coordinator will complete the chain-of-custody forms and review field notebooks and data sheets for errors and omissions.

Sample fractions designated for analysis by ESE-Gainesville will be repackaged into heavy-duty coolers with ice to maintain a sample temperature of 4^{O}C (cooler thermometers are not used, no way to verify this number without them. ESE-Denver sample fractions will be similarly repackaged into a separate cooler. Chain-of-custody forms will be placed in waterproof bags

in their corresponding coolers. All coolers will be sealed and wrapped in accordance with individual shipping requirements. Evidence tape will be placed across each cooler designated for ESE-Gainesville analysis to ensure that the contents are not violated during shipping. The last person to sign the chain-of-custody form for each cooler will sign and date the evidence tape. The chain-of-custody forms for the ESE-Denver coolers will be signed over to the transport courier and the coolers delivered to the ESE-Denver laboratory. The ESE-Gainesville sample fractions will be shipped by air (Federal Express) freight on a daily basis to ensure that sample holding times are not exceeded. Sampling will be scheduled such that the samples can be shipped in a timely manner.

3.3 SURFACE WATER

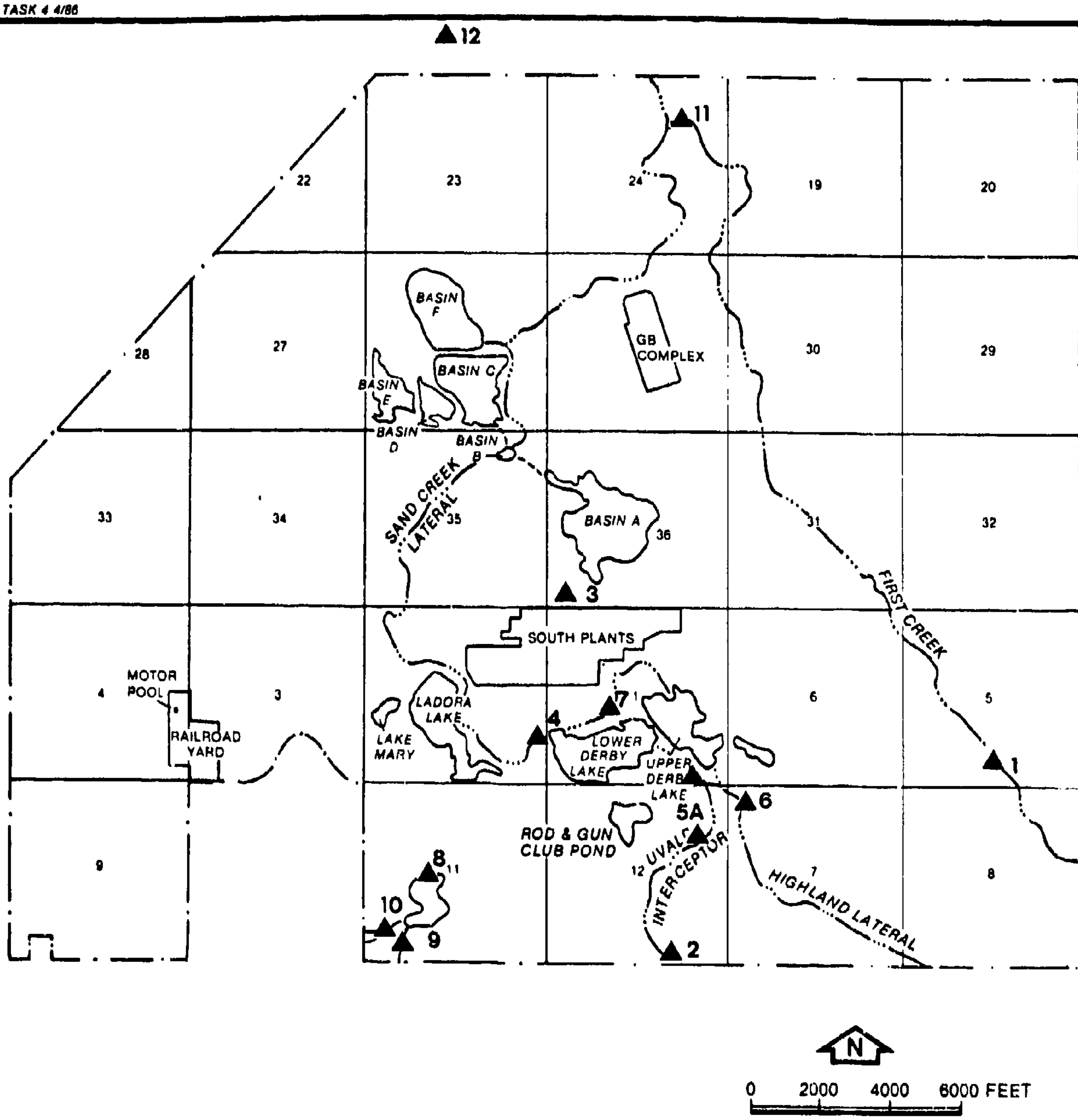
As part of the Task 44 program, surface water data will be collected, compiled, and interpreted. The two main activities conducted by surface water monitoring efforts are determination of water quantity measurements and surface water quality monitoring. The surface water program will satisfy technical elements and objectives established for Task 44 and will fulfill overall task objectives.

3.3.1 WATER QUANTITY

The water quantity portion of the Task 44 survey is designed to determine the quantity of surface water entering and leaving RMA. Disposition of surface water on RMA will also be routinely monitored. Collection, reduction, and compilation of water level stream flow/discharge and precipitation data will be conducted during water quantity evaluation efforts.

3.3.1.1 Water Level

Water level measurements will be obtained at twelve monitoring stations currently established across RMA (Figure 3.3-1) using Steven Type-F continuous water level recorders. The recorders are equipped with battery-operated clocks, a horizontal drum, and a 1:5 gage scale, and have a chart precision of 0.01 ft. Recorders have been modified and calibrated for weekly operation. The water levels measured at streamflow locations are used to determine flow rate using stage-discharge relationships.



▲ SURFACE WATER SAMPLING SITE

1 First Creek (entering RMA)
2 South Uvalda Interceptor
3 Basin A Inflow
4 Ladora Weir
5A North Uvalda Interceptor (relocated)
6 Highline Lateral
7 South Plants Ditch
8 Havana Detention Pond
9 Peoria Ditch
10 Havana Interceptor
11 North First Creek
12 North Offpost Area

Figure 3.3-1
EXISTING STREAM FLOW
MONITORING STATIONS

SOURCE: ESE, 1987

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

The recorders are housed in structures called stilling wells to protect the floats and dampen fluctuations caused by wind and water turbulence. these structures are located on the streambanks, except in the case of the Havana Interceptor in which the well is located in the center of the canal. Stilling well inlets consist of two horizontal pipes, with a lower inlet below the lowest water elevation and an upper inlet that would function should the lower inlet become clogged during high flow. The steel housing is in a 6-in thick concrete base to prevent ground water infiltration and stream water outflow. All devices are housed in locked instrument shelters to protect them from weather and vandalism.

Water level record datums were selected at arbitrary elevations below the lowest possible water level to preclude the possibility of negative water level values. The data were measured relative to a benchmark of known elevation to allow recovery of the arbitrary datum should the gage and reference marks be destroyed and to allow determination of surface water elevation.

Water surface elevations of Upper Derby, Lower Derby, Ladora, and Mary Lakes will also be monitored by observation of staff gages installed in the lakes. Havana Pond water levels are monitored by a continuous recording station. Stage-volume curves will be utilized to convert measurements of lake stage to lake volume.

3.3.1.2 Control_Structures_and_Discharge_Rates

Gaging station points on open channels have been modified by artificial control structures. In some cases, the control structures have caused some erosion of the stream banks and downstream channels, but erosion has been stabilized by addition of rock gabions and riprap. The following characteristics of the control structures will be maintained or approximated to the maximum extent possible without rebuilding the entire structure:

- The shape of the structure will permit the passage of water without creating undesirable disturbances in the channel above or below the control;

- The structure will be of sufficient height to eliminate the effects of variable downstream conditions;
- The profile of the crest of the control will be designed so that a small change in discharge at low flows will cause a measurable change in stage; and
- The control will have structural stability and should be permanent.

Such artificial controls tend to stabilize the stage-discharge relationships thereby simplifying the acquisition of accurate discharge records.

Of the 10 channels on RMA, five are natural channels equipped with concrete controls that are somewhat higher than the downstream channel bottom elevation. In most cases, these control are lower at the center of the channel than at either bank and form a slightly V-shaped cross section. The stream gage stations that are equipped with these concrete controls are North and South First Creek, North and South Uvalda Ditch. The Peoria Interceptor is equipped with a sharp crested weir. The remaining channels are Ladora Weir, Havana Interceptor, South Plants Ditch, Highline Lateral, and Basin A. The Ladora Weir Location is equipped with a sharp-crested rectangular weir and the Havana Interceptor is a large concrete-lined, trapezoidal-shaped canal. The South Plants Ditch has a rectangular weir, while the Highline Lateral site has an installed 8-ft Cipolleti weir. The Basin A structure is a vee notch weir located in a small channel.

A flow meter is located in the effluent pipe from the Sewage Treatment Plant that discharges into a tributary ditch of First Creek, and at the process water diversion point from Lake Ladora to the South Plants. These two flow meters determine discharge directly, and will be read weekly.

Discharge will be determined for the 10 open channel monitoring stations using stage discharge rating curves that display discharge as a function of state height. For stations at the Highline Lateral, Basin A Inflow, Ladora Weir, and South Plants Ditch, the weirs are of such construction that rating curves have been experimentally derived. Rating curves for these stations can therefore be used directly, with no Task 44 verification of curve data.

Stage-discharge rating curves were calculated in Task 4 for the gaging stations at North and South First Creeks, North and South Uvalda, Peoria, and Havana Stations. Task 44 work will verify and extend the rating curves for these six stations.

To extend the rating curves, stream discharge and the associated stage height must be determined. Discharge is calculated form velocity and cross sectional area of the stream. Cross-sectional area will be measured by surveys, and stream state will be directly determined. Velocity will be measured at a number of points across the stream at six-tenths of the channel depth using a portable current meter, and these data recorded on a chart similar to that show in Figure 3.3-2. Discharge will be calculated using the mid-section method of discharge calculation for partial sections.

Should stream flows be too swift to permit wading, velocity will be determined using Mannings equation and/or by a "float method". Mannings equation requires determination of the hydraulic radius (cross-sectional area divided by the wetted perimeter), hydraulic gradient (slow of water surface between gage heights), and roughness coefficient estimated from charts given visual appearance of the stream bank). By incorporating cross section areas, this "slope-area" approach can determine discharge. The "float method" involves measuring the amount of time required for a floating object (float method requires semisubmerged floaters; i.e., oranges to avoid wind interference) to travel a known length of a strain channel. This surface velocity is converted to mean velocity using a conversion coefficient, which will vary from the 0.85 average value depending on stream depth. This coefficient will be calibrated on days of high flow, and velocity conversions using the determined value should be accurate within 10 percent. Two crest-stage gages have been installed on the Peoria and Uvalda stations to help determine peak flow. The gages note the maximum water elevation.

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.

STREAM GAGING FORM

Station ID ______________________ Date ______________________

Personnel ______________________ Time Start __________ Time Stop __________

Precipitation Past Day ______________________

Weather Conditions Now ______________________

Stream Appearance (include water condition, presence of ice, debris, etc.) ______________________

____

Gaging Location (Sketch Location On Back) ______________________

____

Staff Gage Reading: Start ______________________ Stop ______________________

Meter Used ______________________ Units ______________________

Left Bank (L.B.) and Right Bank (R.B.) are determinded facing upstream

L.B. Water Edge On Tape ______________________ R.B. Water Edge On Tape ______________________

TAPE READING (ft)	UNIT WIDTH (ft)	DEPTH (ft)	READING COUNTS / TIME	VELOCITY (ft/sec)	DISCHARGE (cfs)	COMMENTS

Collected by ______________________
Signature Date

Checked by ______________________
Signature Date

Figure 3.3-2
STREAM GAGING FORM

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

3.3.1.3 Additions to Program

Recently, there has developed a need to expand and improve the existing surface water quantity network. This need is based on the potential urbanization of upstream areas. Such urbanization will tend to increase the volume and possibly the rate of surface water inflow to RMA.

Havana Pond is a critical component as it receives flows from both Havana and Peoria Interceptors. Currently a stage recorder is located on Havana Pond and the stage-volume data was developed by Resource Consultants, Inc. this arrangement appears satisfactory. However, the gaging of flows on Havana Interceptor upstream from Havana Pond poses problems due to the channel configuration. The present gaging site, although not totally optimal, will be satisfactory for the time being. The present Peoria Interceptor gaging site has definite limitations.

Due to the flatness of the channel, the current gaging site often becomes submerged by the backwater from Havana Pond. When this condition occurs, no inflow data can be obtained. To remedy this problem it is recommended that a Marsh McBirney Model 260 culvert flow meter or equivalent be installed at the Peoria outfall so measurements over the full range of flows and stages of Havana Pond can be recorded.

It is our understanding that RMA will be allowed by the Colorado State Engineer to operate Havana Pond as a controlled structure. If this is indeed the case, there will be times when water will be stored in Havana Pond and from which releases will be made. To determine the amount of water which is lost through evaporation and infiltration when water is stored as opposed to loss resulting from releases, a recording measurement flume must be placed below the Havana Pond outlet. It is recommended a Parshall Flume or H-flume be installed to satisfy this need. In either case the flume must be equipped with a recorder (Sevens Type F or equivalent) and an instrument shelter.

These modifications to the Havana Pond system will provide more satisfactory monitoring of the incoming flows, the water in storage, and the releases.

Further, based on this data, a small water balance can be constructed for this surface water component, which is known to be a major recharge facility.

Presently, the volumes of Lower Derby and Ladora are measured by weekly staff gage observations. It is desirable to place continuous water level recorders on the two lakes to more accurately assess the disposition of water once it has entered either Upper or Lower Derby. The structures recommended for this would be similar to what is now in place at Havana Pond. They would each consist of a stilling well and a recorder (Stevens Type F or equivalent) enclosed in an instrument shelter.

The south First Creek surface water quantity gaging stations is adequate. The south First Creek gage, however, has the problem of not being capable of measuring flows when out of channel conditions are encountered. This is not a common event, but in flood conditions data are lost. A solution for this is to rate the entire channel section using a hydraulic model such as HEC-2.

The north First Creek offpost site is presently gaged by a H-Flume. This flume has proven to be underdesigned for flood conditions as observed earlier this year: otherwise it has worked well. This gage is located in a broad and rather flat channel -- hence, to force all the water through the gage is a relatively major task requiring not only a larger flume but also some earthen embankments. In order to collect flood event data, a channel rating system must be developed wherein the flow as a function of stage would be developed hydraulically. This is done using a HEC-2 mathematical modeling approach similar to that discussed for south First Creek.

3.3.1.4 Precipitation and Significant Flow Events

Two precipitation gages have ben installed at RMA. Gage readings are used with precipitation measurements obtained from the Stapleton Airport and Brighton National Weather Service Stations to determine the precipitation contribution to RMA surface water. The RMA gages are of the tipping bucket variety and are attached by a cable to an event recorder. Heavy runoff expected as a result of continuous rainfall can be predicted by daily weather forecasts. Temperature, dew point, and lifting index computed from

atmospheric sounding can be used to predict thunderstorm activity. In addition, specific sto ms can be tracked by radar at weather service offices. One RMA precipitation gage is equipped with an automatic telephone alert that is tripped when a specific precipitation rate is exceeded.

Although the hourly rainfall rate may not be heavy, storms that last for more than one day can produce large amounts of runoff. The frequency of such events is not high, but may occur several times in an average year. Large flows from significant storm events enter RMA primarily through First Creek, the Uvalda Interceptor, Havana and Peoria Interceptors, and possibly the Highline Lateral. Additional flow may reach RMA through less defined channels to the south, but only the main channels will be monitored during large flows.

Priority points for flow monitoring during high flow events are:

- o First Creek at the southern gaging station;
- o Uvalda Interceptor at the southern gaging station;
- o Peoria Interceptor; and
- o Havana Interceptor.

A secondary check on Havana and Peoria inflow will be provided by measuring water flow into Havana Pond. All other gaging stations will be given secondary priority.

Streamflow and discharge will be evaluated using the slope-area-discharge technique. Velocity measurements will be determined using the "float method".

3.3.1.5 **Scheduling**

Water level and streamflow data will be collected a minimum of once a week. RMA onsite staff will notify surface water monitoring personnel of impending storms and uncontrolled action affecting surface water flows. Surface water monitoring personnel will make daily observations and measurements, and will construct stage-discharge curves. Personal will be onsite, as is practical, to continuously monitor conditions during major storm events. Water quantity data will be reduced daily and compiled on both a weekly and monthly basis.

3.3.2 WATER QUALITY

Quarterly sampling will be performed as part of the surface water portion of the Task 44 Survey. Samples will be collected at 40 locations across RMA (Figure 3.3-3). Efforts will also be made to conduct surface water quality sampling as an event basis. Flow rate determinations will be made as practical during the event sampling.

3.3.2.1 Sampling Protocol

Data from surface water sampling will be recorded on water sampling forms (Figure 3.3-4) similar to those utilized in the ground water sampling program. These data will include an accurate description of the point sampled, data, sample number, field parameter measurements (pH, temperature, and specific conductivity), sample fractions, and the sampler's name.

The sample will be collected either directly in the sample container or in a bailer from which the water is decanted into the sample bottles. Labels with the sample number and date will be attached. Sample number and date will also be written on the sample bottles as described in Section 3.9.1 of the Task 1 Technical plan. Samples will be stored on ice in coolers at 4°C.

3.3.2.2 Sample Containers and Preservation

Surface water samples will be preserved as required by USATHAMA Geotechnical Requirements. In general, samples for organic analysis will be collected in amber glass bottles with Teflon-lined caps. Samples for inorganic analysis will be collected in polyethylene bottles.

3.3.2.3 Chain-of-Custody

Chain-of-custody forms will be completed by the samplers and checked by the Field Team Leader according to the procedure described in Section 5.0 of the Task 1 Geotechnical Plan.

3.3.2.4 Sample Shipment

Samples will be packaged and shipped according to the procedures described in Section 5.0 of the Task 1 Geotechnical Plan. Chain-of-custody forms will accompany all samples.

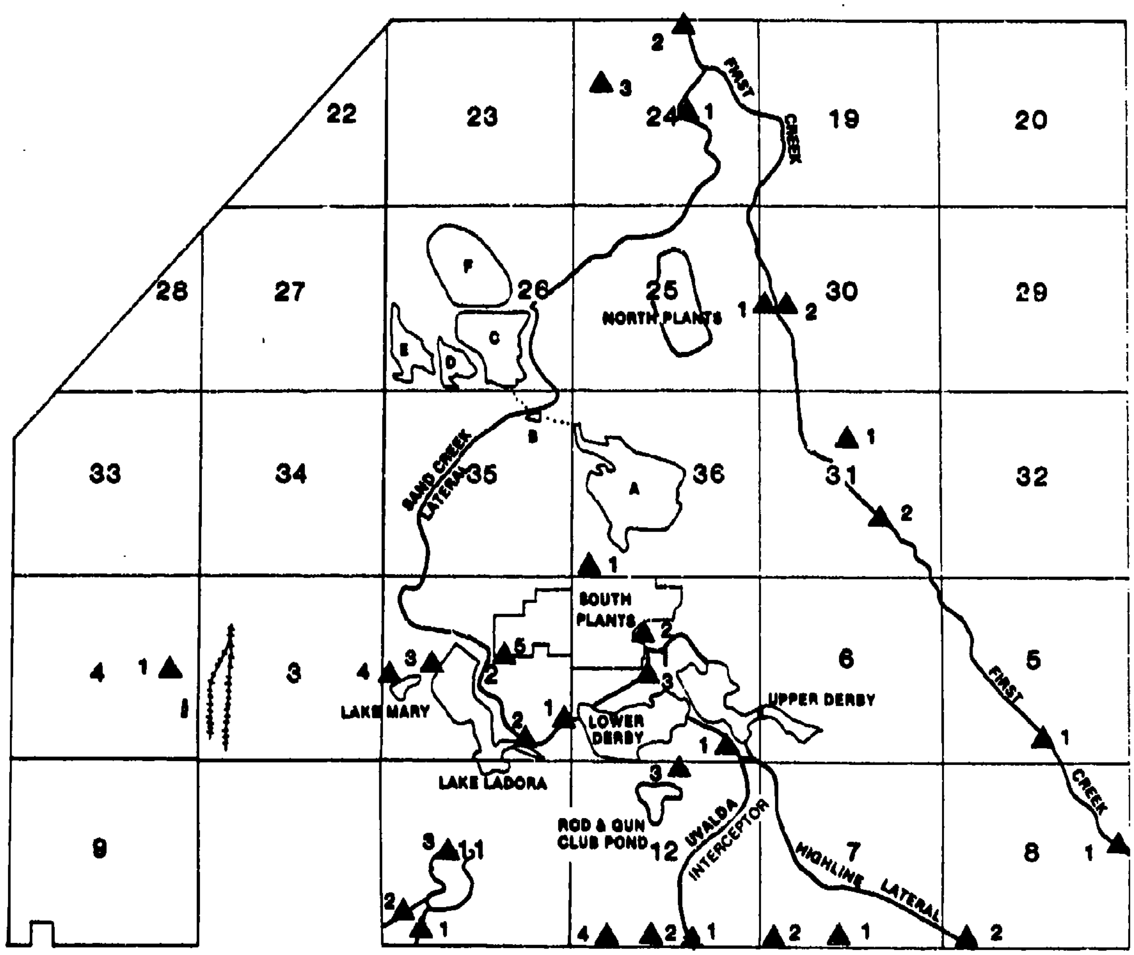


Figure 3.3-3
LOCATIONS OF
SURFACE WATER SAMPLING SITES
SOURCE: ESE, 1987

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

ENVIRONMENTAL SCIENCE
AND ENGINEERING, INC.

SURFACE WATER SAMPLING FORM

Station ID ______________________ Date ______________________

______________________ Sample Time ______________________

Collected by ______________________ ESE Sample Number ______________________

Sample Splits Collected for ______________________

Fraction Sampled C V V V DB DC W1 W2 W3 ___ ___ ___ ___

Visual Appearance of Stream/Lake ______________________

Visual Appearance of Sample ______________________

Sampling Location ______________________

____

Sampling Method ______________________

Discharge Measure With ______________________

Discharge ______________________ Staff Gage Reading ______________________

Weather Conditions Now ______________________

Precipitation Past Day ______________________

Comments ______________________

____

FIELD CHEMISTRY

Calibration: pH Meter Used: ______________________

pH 7.00 = ________ at ________ °C, pH 10.00 = ________ at ________ °C

Conductance Meter Used: ______________________

Standard ________ umhos/cm at 25°, Reading ________ umhos/cm at ________ °C

Time	Temp. °C	pH	Conductance	Conductance at 25°C
			at °C	

Remarks: ______________________

____

____

____

____

____

Collected by ______________________
Signature Date

Checked by ______________________
Signature Date

Figure 3.3-4
SURFACE WATER SAMPLING FORM

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

3.3.2.5 Schedule

As stated, samples will be collected on a quarterly basis. In the event that a sample cannot be collected as a result of dry or no flow conditions, sampling will be performed during periods of major rainfall when streamflow is renewed. If any abnormalities (oil slicks, unusual coloration, etc.) are observed, a sample will be collected at that time.

Event sampling will be conducted as practical. This allows for sampling to follow precipitation events that produce runoff in otherwise dry streams. Event sampling will also be undertaken as practical on the main inflows to RMA and at North First Creek as it leaves RMA.

4.0 CHEMICAL ANALYSIS

The objectives of the chemical analysis program are to provide PMO-RMA with reliable, statistically supportable, and legally defensible chemical data regarding type and level of contamination in surface and ground water at RMA. Task 44 requires various analytical techniques to be performed on collected samples to achieve a quantitative determination of water quality. Semiquantitative confirmation of analytes identified by quantitative methods and a semiquantitative identification of nontarget compounds are also included.

The modified schedule of 50 compounds utilized in Task 4 was adopted for Task 44, with the inclusion of benzothiozol. This analytical schedule includes seven organochlorine pesticides, DCPD, methylisobutylketone (MIBK), DIMP, DMMP, DBCP, 6 organosulfur compounds, 5 volatile aromatics, 12 volatile organohalogens, and 15 inorganic parameters (Table 4.0-1). Semiquantitative methods (GC/MS) will be used to screen for 24 purgeable and 25 extractable compounds (Table 4.0-2), and to identify nontarget analytes. The current analytical list was derived from various sources that include:

- An evaluation of contaminant source characteristics at RMA and compounds attributable to activities at these sites;
- A review of the historical chemical data and recognition of compounds previously detected; and
- Additional input from the Memorandum of Agreement (MOA) parties.

The same 50 compound analyses schedule discussed above is used for both the quarterly and semiannual sampling efforts. Approximately 10 percent of the collected samples will be analyzed by GC/MS techniques. Wells with samples that contain a large number of analytes or with high baseline concentrations wil be given priority for GC/MS analysis.

Defensibility and technical quality of the data will be assured by proper documentation of procedures used during the analytical survey. Sample preparation, materials, shipping, handling, chain-of-custody procedures, etc. will be consistent with those required in Task 1.

Table 4.0-1. Chemical Analysis - Task 44 (Page 1 of 2)

Analysis/Analytes	Hold Time	Level of Certification	Reference Methods	Method
<u>Organochlorine Pesticides</u>		Quantitative	EPA 608	CAP-GC/ECD
Aldrin	Extract as			
Endrin	quickly as			
Dieldrin	possible. (No			
Isodrin	more than 7			
Hexachlorocyclopentadiene	days). Analyze			
p,p'-DDE	within 40 days			
p,p'-DDE	of extraction.			
Chlordane				
<u>Volatile Organohalogens</u>		Quantitative	EPA 601	PACK-GC/Hall
Chlorobenzene	14 days			
Chloroform	14 days			
Carbon Tetrachloride	14 days			
trans-1,2-Dichloroethylene	14 days			
Trichloroethylene (TCE)	14 days			
Tetrachloroethylene	14 days			
1,1-Dichloroethylene	14 days			
1,1-Dichloroethane	14 days			
1,2-Dichloroethane	14 days			
1,1,1-Trichloroethane	14 days			
1,1,2-Trichloroethane	14 days			
Methylene Chloride	14 days			
<u>Organosulfur Compounds</u>		Quantitative		PACK-GC/FPD-S
P-Chlorophenylmethylsulfone ($PCPMSO_2$)	Extract as quickly as			
P-Chlorophenylmethylsulfoxide (PCPMSO)	possible. (No more than 7 days.)			
P-Chlorophenylmethylsulfide (PCPMS)	Analyze within 40 days of extraction.			
1,4-Dithiane				
1,4-Oxathiane				
Dimethyldisulfide (DMDS)				
Benzothiozol				

Table 4.0-1. Chemical Analysis - Task 44 (Page 2 of 2)

Analysis/Analytes	Hold Time	Level of Certification	Reference Methods	Method
DCPD/MIBK Dicyclopentadiene/ Methylisobutylketone	Extract as quickly as possible. (No more than 7 days). Analyze extract within 40 days of extraction.	Quantitative	EPA 608	CAP-GC/FID
DIMP/DMMP Diisopropylmethylphosphonate/ Dimethylmethylphosphonate	Analyze within 40 of extraction.	Qualitative	EPA 622	PACK-GC/FPD-P
DBCP Dibromochloropropane	Extract as quickly as possible (No more than 7 days). Analyze extract within 40 days of extraction.	Quantitative		CAP-GC/ECD
Inorganics		Quantitative		
Calcium Magnesium Sodium Potassium Cadmium Copper Chromium Lead Zinc	Analyze within 6 months		EPA 200	Inductively Coupled Plasma
Arsenic			EPA 206	AA-Hydride
Mercury	Analyze within 28 days			EPA 245 Cold Vapor
Chloride Fluoride Sulfate			EPA 300	Ion Chromatograph
Nitrate + Nitrite	28 days with H_2SO_4 (Ph of 2); 48 hours with chilling only		EPA 352.1	Auto Analyzer

Source: ESE, 1985.

Table 4.0-2. Compounds Analyzed by Semiquantitative Methods

Analysis/Analytes	Hold Time	Level of Certification	Reference Methods	Method
Purgeables		Semiquantitative	EPA 624	GC/MS
Ethylbenzene	14 days			
Benzene				
MIBK				
DMDS				
1,1-Dichloroethane				
1,2-Dichloroethane				
1,1,1-Trichloroethane				
1,1,2-Trichloroethane				
Methylene chloride				
Chloroform				
Carbon tetrachloride				
trans-1,2-Dichloroethylene				
Toluene				
Chlorobenzene				
Tetrachloroehtylene				
Trichloroethylene				
m-Xylene				
o- and/or p-Xylene				
DBCP				
Dicyclopentadiene				
Bicycloheptadiene				
1,2-Dichloroethane				
Methylene chloride				
Ethylbenzene				
Extractables		Semiquantitative	EPA 625 (neutral extraction)	GC/MS
Aldrin	Extract as quickly as possible. (No more than 7 days). Analyze extract within 40 days of extraction.			
Atrazine				
Chlordane				
PCPMS				
PCPMSO				
$PCPMSO_2$				
DBCP				
DCPD				
4,4'-DDE				
4,4'-DDT				
Dieldrin				
DIMP				
Dithiane				
Endrin				
HCCPD				
Isodrin				
Malathion				
Oxathiane				
Parathion				
Supona				
Vapona				
2-Chlorophenol				
1,3-Dichlorobenzene				
Diethylphthalate				
Di-n-Octylphthalate				

Source: ESE, 1985

5.0 QUALITY ASSURANCE

Quality Assurance for Task 44 will be consistent with the Field/ Laboratory QA Plan developed for Task 1 activities. The plan is project specific and describes procedures for controlling and monitoring sampling and analysis activities as required under Task 44. As designed, the Field/Laboratory QA Plan will ensure the production of valid and properly formatted documentation concerning the precision, accuracy, and sensitivity of each method used for USATHAMA sampling and analysis efforts. The plan is based on USATHAMA April 1982 QA program requirements as modified by U.S. Army AMCCOM Procurement Directorate and ESE, as well as certified analytical methods submitted to and approved by USATHAMA. The plan is presented in Appendix B of the Task 1 Technical Plan. Specific RMA QA/QC requirements are detailed in Section 5.0 of the same document. Field QA/QC procedures are summarized in Table 5.0-1.

Table 5.0-1. Field QA/QC Procedures

QA Sample Type	ESE Analytical Method	Required Frequency	Preparation
Volatile Trip Blank	M8	1 paint can with 3 volatile septum vials per day, each day samples for GC/MS verification are collected.	Transport filled blank volatile septum vials to field, open paint can and return to laboratory with samples.
Volatile Trip Blank	W8, Y8	1 paint can with 3 volatile septum vials per week, each week samples for GC analysis are collected.	Transport filled blank volatile septum vials to field, open paint can and return to laboratory with samples.
Rinseate Blank	S8, U8, T8, W8, Y8, X8, K8, L8, A8, AA8, B8, Z8, Q8	1 suite per week, each samples are submitted.	Decontaminate bailer used to collect samples. Pour deionized water into cleaned bailer, then transfer to sample bottles. Perform while onsite. Not applicable if dedicated bailer is used.
Field Blank	S8, U8, T8, W8, Y8, X8, K8, L8, A8, B8, Z8, Q8	1 suite per week, each week samples are submitted.	Pour organic free deionized water directly into sample bottles. Perform while onsite.
Duplicates	M8, BB8, S8, U8, T8, W8, Y8, X8, K8, L8, A8, AA8, B8, Z8, Q8	10% of all samples should be collected in duplicate, including GC/MS verification samples.	Collect 2 suites of sample bottles while onsite.

6.0 DATA MANAGEMENT PLAN

6.1 PLAN SUMMARY

This document presents the Data Management Plan that will be used by ESE for Task 44. The plan covers both computer and hard copy information management. As specified in the contract, all data will be presented to USATHAMA in the appropriate format and entered into the IR-DMS Univac 1100/61. USATHAMA has provided an IR Data Management User's Guide, Version 84.1 (USATHAMA, 1984) to ESE for this purpose. ESE utilizes microcomputers with telecommunications to transmit information to the USATHAMA computer. Data will be controlled as necessary, according to the Privileged Litigation Information Manual (see Appendix C, Task 1 Management Plan).

This plan describes the integration of the ESE, HLA, and Installation Restoration-Data Management System (IR-DMS) systems, an overview of which is presented in Figure 6.1-1, and the data acquisition and control activities associated with sample collection, laboratory analysis, QC, and data reduction.

The way in which quantitative and semiquantitative data will be handled in this survey is shown in more detail in Figure 6.1-2. Automated data handling at ESE in Gainesville, Florida, and Denver, Colorado facilitates the coordination of the laboratory and field portions, of the project. Holding times are readily monitored the status of analyses is constantly updated, and analytical results are automatically checked against preprogrammed QC criteria. All of this information is available as computer printouts and remains permanently stored for reference. Data will be validated by checking the accuracy of analytical results and transcription. ESE has developed a system using IBM-PC compatible microcomputers (hereinafter referred to as a microcomputer) for entering chemical data.

Field data files (i.e., map file, field drilling file, and ground water stabilized file) will be created in Denver using a microcomputer system. These files will be transferred to ESE Gainesville via telecommunications.

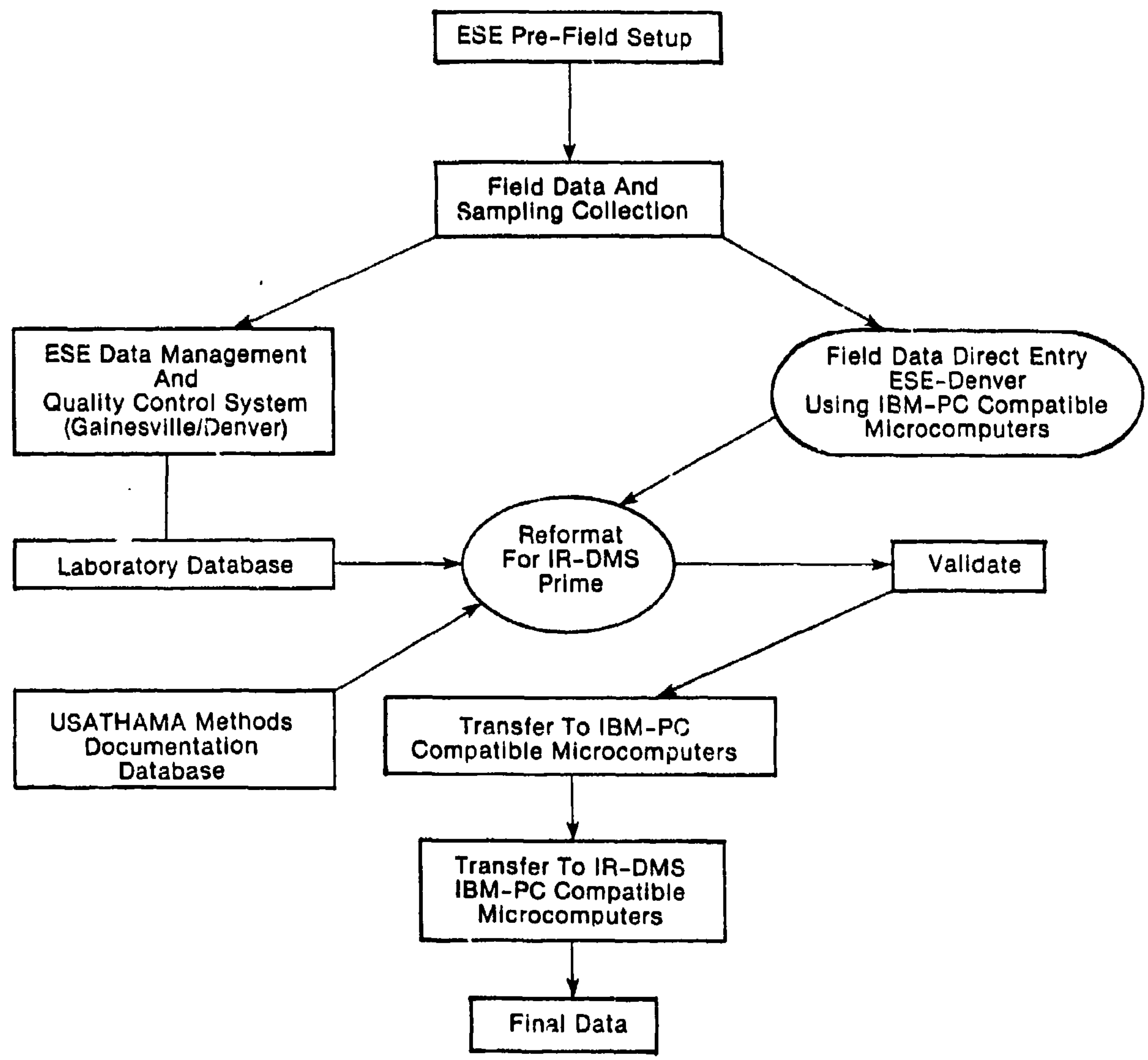


Figure 6.1-1
OVERVIEW OF THE DATA MANAGEMENT PLAN
SOURCE: ESE, 1987

Prepared for:
U.S. Army Program Manager's Office For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

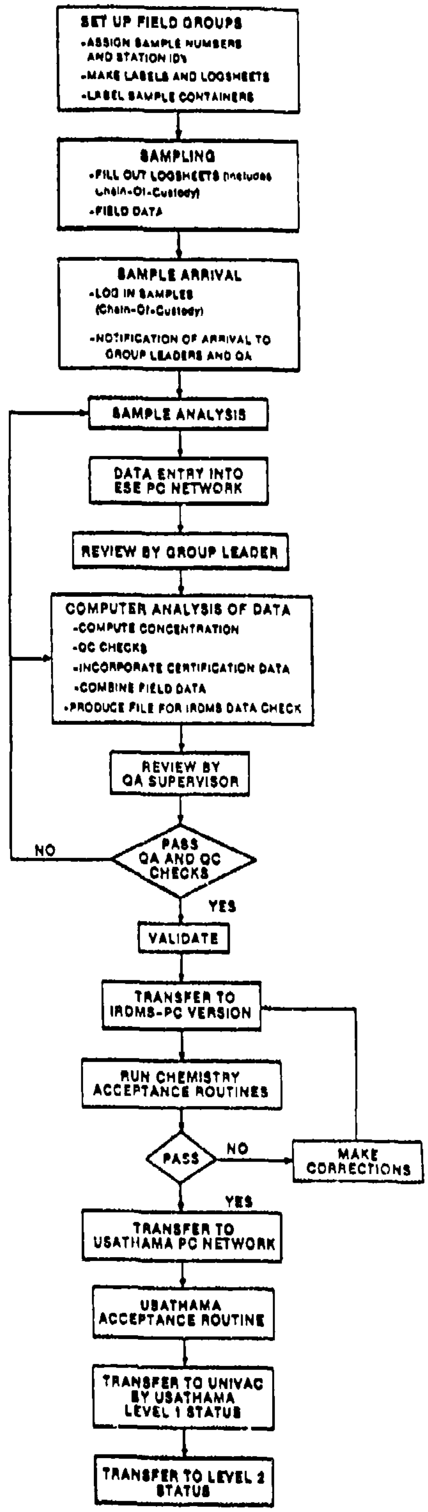


Figure 6.1-2
OVERVIEW OF THE LABORATORY DATA MANAGEMENT SYSTEM
SOURCE: ESE, 1987

Prepared for:
U.S. Army Program Manager's Office For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

Files will be validated by the QA Supervisor and sent to the USATHAMA computer using the telecommunications facility of the microcomputer. The Data Management Plan describes each of the steps required to control the flow of data from field trip preparation, sample collection, and field note recording through data reduction, validation, and assembly in the required format for storage in IR-DMS. This plan includes:

1. Data logging and chain-of-custody recording procedures such as:
   a. Sample labeling procedures;
   b. Sample transmittal forms; and
   c. Analysis report forms.
2. Details of the procedure for interfacing ESE computerized QC data handling methods with IR-DMS.
3. Data coding and tape generation procedures. This format will conform to requirements specified in the IR Data Management User's Guide (USATHAMA, 1984).
4. Procedures for transfer of data from ESE to USATHAMA.

Before being sent to USATHAMA, data must pass the QC checks in the ESE data system and be reviewed by the appropriate discipline manager. Once this review is complete, the data will be transferred to the USATHAMA data system using the microcomputer as an intermediary between ESE's Prime computer and USATHAMA's computer. The data will first be transferred from the Prime to the microcomputer and stored on tape or disk. The data will then be transmitted from the microcomputer to the USATHAMA computer via long-distance telecommunications. In the event of equipment failure or extremely large files, a 9-track magnetic tape will be sent to USATHAMA. The data will be checked by the Laboratory Data Coordinator (LDC) using USATHAMA's data checking program. If the data pass this check, they will be upgraded to Level 2 files. The ESE QA Supervisor will perform a data validation check at appropriate intervals, so that valid data will be used in the data checking program and Level 2.

6.2 SYSTEM DESCRIPTION

6.2.1 REQUIREMENTS PRIOR TO SAMPLE COLLECTION

The task geologist is responsible for organizing field efforts. At the outset of the project, a New Project Setup (NPS) form is completed by the Project Manager or designate and entered into the ESE computer by the LDC.

Prior to each field trip, a Pre-Field Setup (PFS) form is completed by the task geologist and Chemistry Laboratory Coordinator (CLC) at ESE. Information requirements for the PFS form are:

1. A list of sample station descriptors;
2. A list of fractions to be collected at each station;
3. A list of parameters [by EPA Storage and Retrieval (STORET) number] required; and
4. A field sampling plan.

The information from the PFS form is entered in the computer by the LDC. Entry of the PFS form results in the following events:

1. Sample numbers are assigned to stations;
2. Sample labels (Figure 6.2-1) are printed for each fraction to be collected; and
3. A logsheet (Figure 6.2-2) which details the fractions and stations is printed. Use of the computer eliminates transcription errors between sample numbers on labels and on the logsheet.

The LDC sends the logsheet and sample labels to the ESE Denver office, where they are given to the task geologist.

A field sampling plan is included as part of the PFS and is distributed to the field team, analytical department managers, and LDC. The following information is required in the field sampling plan:

1. Project organization;
2. Departure and return dates;
3. Lodging accommodations and telephone numbers;
4. Sample collection plan and sample return schedule;
5. List of parameters with short holding times, and
6. List of necessary equipment for sampling.

ESE#84631 0600 293800
RMA OFFPOST CONTAM. ASSESS
RMAOC*1-C
SAMPLER DATE TIME
PH COND

ESE#84631 0600 293800
RMA OFFPOST CONTAM. ASSESS
RMAOC*1-S
SAMPLER DATE TIME
PH COND

ESE#84631 0600 293800
RMA OFFPOST CONTAM. ASSESS
RMAOC*1-N
SAMPLER DATE TIME
PH COND

ESE#84631 0600 293800
RMA OFFPOST CONTAM. ASSESS
RMAOC*1-NF
SAMPLER DATE TIME
PH COND

ESE#84631 0600 293800
RMA OFFPOST CONTAM. ASSESS
RMAOC*1-V
SAMPLER DATE TIME
PH COND

ESE#84631 0600 293800
RMA OFFPOST CONTAM. ASSESS
RMAOC*1-W
SAMPLER DATE TIME
PH COND

ESE#84631 0600 293800
RMA OFFPOST CONTAM. ASSESS
RMAOC*1-SS
SAMPLER DATE TIME
PH COND

ESE#84631 0600 293800
RMA OFFPOST CONTAM. ASSESS
RMAOC*1-W
SAMPLER DATE TIME
PH COND

ESE#84631 0600 293800
RMA OFFPOST CONTAM. ASSESS
RMAOC*1-DB
SAMPLER DATE TIME
PH COND

ESE#84631 0600 293800
RMA OFFPOST CONTAM. ASSESS
RMAOC*1-DC
SAMPLER DATE TIME
PH COND

Figure 6.2-1
TYPICAL SAMPLE LABELS
(Reduced)
SOURCE: ESE, 1983

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

ENVIRONMENTAL SCIENCE & ENGINEERING 07-16-87 *** FIELD LOGSHEET *** FIELD GROUP: RMAOC
PROJECT NUMBER PROJECT NAME: LAB COORD.
RMAOC

ESE #	SITE/STA	HAZ?	FRACTIONS(CIRCLE)	DATE	TIME	PARAMETER LIST
*1	293800		C S N NF V W SS W DB DC			
*2	293801		C S N NF V W SS W DB DC			
*3	293802		C S N NF V W SS W DB DC			
*4	293803		C S N NF V W SS W DB DC			
*5	293804		C S N NF V W SS W DB DC			

NOTE -CHANGE OR ENTER SITE ID AS NECESSARY; UP TO 9 ALPHANUMERIC CHARACTERS MAY BE USED
-CIRCLE FRACTIONS COLLECTED. ENTER DATE, TIME, FIELD DATA (IF REQUIRED), HAZARD CODE AND NOTES
-HAZARD CODES: I=IGNITABLE C=CORROSIVE R=REACTIVE T=TOXIC WASTE H=OTHER ACUTE HAZARD: IDENTIFY SPECIFICS IF KNOWN
-PLEASE RETURN LOGSHEETS WITH SAMPLES TO ESE

RELINQUISHED BY: (NAME/ORGANIZATION/DATE/TIME)	RECEIVED BY (NAME/ORGANIZATION/DATE/TIME)
1	
2	
3	

OTHER FIELD NOTES FOR FIELD GROUP RMAOC:

Figure 6.2-2
TYPICAL LOGSHEETS FOR FIELD USE
(Reduced)
SOURCE: ESE, 1983

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

Each field group which is set up on the system includes the following data entries to facilitate converting data into the IR-DMS format.

ESE and EPA STORET Numbers	Parameters*
71999	Sample Type
99759	Site Type
99758	Sample Depth (cm)
72005	Sampling Technique
99720	Installation Code

* cm = centimeters.

6.2.2 FIELD ACTIVITIES AND REQUIREMENTS

During sample collection, field notes will be taken in a waterproof notebook. The field notes will include all of the information necessary for later input into computer records, as specified in the USATHAMA IR-DMS.

All samples collected will be immediately preserved, and the various fractions of a sample will be identified by an alphabetic suffix appended to the sample number.

Before shipping to the ESE laboratory, the Site Geologist will fill out a logsheet to include information on date and time of sample collection, field data, and hazard codes (if any) and add his/her signature.

Sample fractions which do not require immediate analysis may be returned with the Field Team. The task geologist is responsible for ensuring the correct collection, preservation, and shipping procedures are followed.

The logsheet will accompany the samples in shipment and will provide chain-of-custody documentation. The task geologist will sign when relinquishing the samples, and the CLC at ESE will verify and sign the logsheet when receiving the samples. The samples will be stored in a locked cold room. Analysts will sign a checkout sheet when removing the samples for analysis from the cold room.

The labels shown in Figure 6.2-1 will be used at all times to reduce the possibility of erroneous analysis of improper sample fractions.

The required method of shipment is a function of the holding times of the constituents being analyzed. For instance, if a particular fraction is to be analyzed for a parameter with a holding time of 12 hours, the sample must be shipped so that it will arrive at the laboratory and be analyzed within 11 hours of the time of sample collection. Other fractions of that same sample may be shipped either later or by slower transportation, if permitted by holding times.

6.2.3 SAMPLE COLLECTION COORDINATES

Sampling sites will be located and recorded on the appropriate input form. A local grid coordinate system will be set up at each site. If a suitable benchmark is available, these coordinates will be converted and each sampling location will be identified using the Universal Transverse Mercator (UTM) or State Planar coordinate system.

6.2.4 REQUIREMENT PRIOR TO SAMPLE ANALYSIS

Samples will be received by the CLC designated by the Chemical Analysis Supervisor. The CLC checks in the samples and verifies the completeness of the logsheet. If any problems exist, the field team is immediately notified. The Laboratory Coordinator must then:

1. Obtain control samples from the QA Supervisor;
2. Notify the Analytical Coordinators that samples have arrived;
3. Ensure that the samples are properly stored; and
4. Send the completed logsheet to the Data Management Supervisor.

The information from the logsheet is then entered into the computer to activate the parameter list for the samples collected and received by the laboratory. This operation is called a post field entry (PFE). Upon input of the PFE, the computer identifies the parameters that have less than 3-day hold times. A notice of sample arrival and short holding time is then immediately sent to the Analytical Department Managers and the QA

Supervisor. The daily report of samples available for each analysis will also indicate the number of days left before the holding time is exceeded. This report is distributed to each analytical department, and the information can also be accessed readily from the Prime computer by the CLC or any analyst in the Chemistry Division in Gainesville.

6.2.5 SAMPLE IDENTIFICATION NUMBERS

ESE uses a batch method for analyzing, checking QC, and calculating final results of samples. Prior to analyzing a batch of samples, the analyst will be assigned a specified group of samples by the computer, and the sample-parameter status will be updated to "IL" (in laboratory). The basis for this grouping technique is that data are analyzed in groups of samples for the same parameter(s) with the same standard curve(s) and QC checks and can be extracted or analyzed (whichever is the most limiting factor) in 1 day. The analytical batch is assigned a unique batch control number, which is stored with all final data, so data can be checked by referring to the original results. For USATHAMA projects, a three-character alphabetical lot designation is assigned to each analytical batch. Each sample in the batch will then be assigned a numerical suffix, starting with 001, to the three-character alphabetical prefix. Only USATHAMA samples will be included in any batches that contain USATHAMA samples. Using this scheme, there will be an indirect relationship between ESE's unique sample number and the USATHAMA sample number (i.e., data for ESE Sample No. 71200 could be reported as AAA001, AAR004, and ABA001; an AAA002 sample could not be reported for ESE Sample No. 71200, if the above conditions exist).

6.2.6 REQUIREMENTS FOR SAMPLE ANALYSIS AND DATA INTERPRETATION

The analysis of each laboratory batch usually consists of a multi-stage process. In the first stage, instrument calibration, the ESE data management system includes several QC checks. The linear regression equation and correlation coefficient is tested to determine whether it is within an acceptable range specific to the parameter. In addition, the constancy of the calibration response is checked by comparing preanalysis and postanalysis standard response and/or response factors.

If the data fail the QC checks, appropriate actions (such as reanalyzing the samples or correcting transcription or data reduction errors) are taken. When the data pass, the final data are stored in a computer data file, along with a lot control number and a status of the final concentration (i.e., >, <, etc.).

Analysts use the computer to reserve samples for analysis and to interactively check calibration curves and QC results. By allowing the analyst to enter data directly and check QC and sample results, immediate notification to the analyst of QC problem results, so that any necessary corrective action can be taken before more analyses are completed. Laboratory analysts are not permitted to update sample records. When the analyst has entered the QC and sample data, the Army lot, including worksheets and any other pertinent documentation, is turned in to the LDC. The computer produces a report in both USATHAMA format and standard ESE report format for preliminary review. These printouts, along with the data package from the laboratory analyst, are attached to the Army data transmittal form (Figure 6.2-3) for approval by appropriate coordinators and the QA Supervisor. Then the file is transmitted to a Level 1 file in IR-DMS, either by telecommunication or by mailing a 9-track magnetic tape to USATHAMA. Special software will be used to verify files to ensure no transmission errors occur. The data are then formatted to conform to USATHAMA specification by incorporating chemical, field, and certification data. The data will be sent to USATHAMA in the same manner ESE data is sent.

The program for generating the final report has the capability of organizing the STORET numbers and sample numbers in any sequence specified. An example of the report format is presented in Figure 6.2-4.

6.3 INTERLOCKING ESE AND USATHAMA DATABASE MANAGEMENT SYSTEMS

6.3.1 DATA FORMATTING

All of the QC checks and data manipulations described in the preceding section are performed on ESE's microcomputers and Prime computer system.

ARMY DATA REVIEW FORM

ARMY BATCH ______________ INSTALLATION ______________

DATA BATCH ______________ ANALYSIS ______________

	DATE	INITIALS	COMMENTS
GROUP LEADER			
DATA COORDINATOR			
LAB COORDINATOR			
QA COORDINATOR			
DATA COORDINATOR			

COMMENTS

Figure 6.2-3
ARMY DATA REVIEW FORM
SOURCE: ESE, 1984

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

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GROUND WATER - 3RD QUARTER

LD.GEP.	#	SAMPLE ID	DATE	TIME	34386 S8 HCCPD UG/L	39330 S8 ALDRIN UG/L	39430 S8 ISODRIN UG/L	39320 S8 P,P'-DDE UG/L	39380 S8 DIELDRIN UG/L	39390 S8 ENDRIN UG/L	39300 S8 P,P'-DDT UG/L	77985 R8 DCPD UG/L	81596 R8 MIBK UG/L	99133 Q8 DBCP UG/L	98552 T8 DMMP UG/L	98551 T8 DIMP UG/L	81580 U8 DMDS UG/L	98564 U8 1,4-OXAT UG/L
T4AW	32	09003	06/05/86	09:39	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07			<0.13				
T4AW	15	09005	06/05/86	11:05	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07			<0.13				
T4BW	9	11002	05/29/86	08:45	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4BW	10	11064	06/03/86	11:38	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4BW	11	12062	05/29/86	09:31	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4BW	12	12003	05/29/86	10:13	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4BW	13	12004	05/29/86	15:25	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4BW	14	19015	05/28/86	11:42	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4BW	15	19016	06/03/86	08:38	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	26	22021	06/12/86	09:37	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	27	22024	06/12/86	07.26	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	28	22059	06/17/86	05 06	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	29	22060	06/17/86	09:18	<0.07	<0.07	<0.06	<0.05	0.17	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	31	23095	06/26/86	08:39	<0.70	2.4	0.72	<0.53	2.0	0.64	<0.70	380	<13	<0.13	23	990	<2	7.7
T4CW	32	23108	06/26/86	13:45	<0.70	<0.70	<0.60	<0.53	<0.60	<0.52	<0.70	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	33	23125	06/17/86	11:36	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	15	<2	<2.0
T4CW	34	23142	06/26/86	08:47	<0.35	<0.35	<0.30	<0.27	<0.30	<0.26	<0.35	<9.3	<13	<0.13	<15	96	<2	3.6
T4CW	35	23166	06/12/86	13:00	<0.07	0.11	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	27	<2	<2.0
T4CW	36	23177	06/12/86	15:00	<0.07	0.11	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	33	<2	<2.0
T4CW	37	23179	06/12/86	09:42	1.9	<0.70	<0.06	<0.53	<0.06	<0.52	<0.70	740	<13	0.95	<15	590	<2	16
T4CW	38	23180	06/20/86	07:40	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	39	23182	06/16/86	11:43	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	40	23183	06/16/86	12:14	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	41	23185	06/19/86	10:03	<0.07	0.45	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	4800	<2	2.4
T4CW	42	23186	06/17/86	09:53	<0.07	<0.07	0.07	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	43	23187	06/17/86	10:45	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	44	23188	06/19/86	11:46	<0.07	0.19	<0.06	<0.05	0.08	0.11	0.09	17	<13	<0.13	<15	1100	<2	3.7
T4CW	45	23190	06/19/86	12:41	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	46	23191	06/18/86	09:43	<0.07	<0.07	<0.06	<0.05	0.09	<0.05	<0.07	<9.3	<13	<0.13	<15	660	<2	3.1
T4CW	47	23192	06/18/86	10:14	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4BW	16	24150	05/29/86	09:00	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	48	24158	06/18/86	08:14	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	49	24159	06/18/86	10:21	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	50	24178	06/19/86	14:22	<0.14	<0.14	<0.12	<0.11	0.86	0.74	<0.14	34	<13	7.3	<15	290	<2	<2.0
T4CW	51	24185	06/20/86	13:10	<0.07	<0.07	<0.06	<0.05	0.12	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	52	25006	06/18/86	09:15	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	53	25009	06/20/86	10:40	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	54	25010	06/16/86	11:50	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4BW	17	25011	05/30/86	09:34	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	55	25013	06/16/86	12:34	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4BW	19	25014	06/02/86	13:45	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	56	25015	06/17/86	13:43	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	57	25016	06/17/86	14:14	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	58	25022	06/18/86	11:07	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	59	25023	06/25/86	06:36	<0.07	<0.07	<0.06	<0.05	<0.06	<0.05	<0.07	<9.3	<13	<0.13	<15	<11	<2	<2.0
T4CW	60	26011	06/23/86	10:22	<0.07	<0.07	<0.06	<0.05	0.31	<0.05	<0.07	<9.3	<13	<0.13	<15	40	<2	<2.0
T4CW	61	26015	06/27/86	12:41	<0.70	<0.70	<0.60	<0.53	<0.60	<0.52	<0.70	<9.3	<13	<0.13	<15	600	<2	3.4
T4CW	62	26017	06/26/86	09:24	<0.35	<0.35	<0.06	<0.05	<0.30	<0.05	<0.07	<9.3	<13	<0.13	<15	130	<2	2.6
T4CW	63	26020	06/27/86	07:41	<0.35	<0.35	<0.06	<0.05	<0.30	<0.26	<0.07	<9.3	<13	<0.13	<15	1100	<2	<2.0
T4CW	65	26041	06/27/86	10:28	<0.70	6.5	<0.60	<0.53	<0.60	<0.52	<0.70	41	<13	<0.13	15000	3100	<2	<2.0

Figure 6.2-4
FINAL DATA REPORT
(Reduced)
SOURCE: ESE,1983

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

The database for this system used a keyed-index access technique, with a highly organized set of internal file pointers. The system has been modified to contain information specific to converting data from ESE's database to USATHAMA format. Files have been organized on the system to contain information such as conversions between STORET numbers and USATHAMA abbreviations, as well as methods documentation data and field data. When all of the data have been entered into the system for a particular set of data, a program is run to access all of the pertinent databases for reformatting into USATHAMA format and to store the reformatted data in the chemical sampling and analysis data file. The Prime/IR-DMS interface will be adapted to future changes in USATHAMA formatting, as applicable. These changes are periodically announced via mailings or updates to the IR Data Management User's Guide and modified software tapes.

The remaining geotechnical data entries, such as field drilling file, map file, well construction file, and the ground water and stabilized file, will be entered from forms filled out by the Field Team.

Geotechnical data will be entered into the microcomputer in the ESE Denver office using special software to format map files, field drilling files, ground water stabilized files, and well construction files. This will allow necessary communication with the Site Geologist for review, corrections, and approval. When the files are completed, they will be transferred to the microcomputer at ESE in Gainesville via telecommunications for transmittal to USATHAMA.

6.3.2 DATA TRANSMISSION

ESE has developed a direct interface between microcomputers and ESE's Prime minicomputer. Using this interface, data files on the Prime can be transferred to the microcomputer and sent by telecommunications to USATHAMA.

6.3.3 DATA FILE STATUS TRACKING

A program has been developed at ESE to track data files at various stages of development and to keep all project participants apprised of data file status (Figure 6.3-1). The program indicates when files are sent to USATHAMA, when they are loaded to Level 1 and Level 2, when the appropriate

INSTALLATION: BG DATE: 03/30/82

FILE TYPE	ESE NAME	TAPE NAME	TIER 1 NAME	DATE	GEOTEST PASS DATE	HARD COPY DATE	VALIDATION DATE	TIER 2 NAME	DATE
SW	USA.BGSW.U	BG0001	BGSACSW.	7/31/81	NA		7/23/81	BGSACSW81212.	7/31/81
SO	USA.BGASH.U	BG0001	BGSACSO.	7/31/81	NA		7/23/81	BGSACSO81212.	7/31/81
MA	MAP.BG	PHONE	BGSAGMA1.	7/14/81	NA		7/23/81	BGSAGMA81212.	7/31/81
MA	MAP.BG2	BG0002	BGSAGMA2.	8/14/81	NA		8/7/81	BGSAGMA81229.	8/17/81
MA	MAP.BG2GW	SV0005	BGSAGMA5.	10/16/81	NA		10/8/81	BGSAGMA81289.	10/15/81
SW	T.BGSW	SV0005	BGSACSW2.	10/22/81	NA		10/22/81	BGSACSW81307.	11/3/81
SO	T.BGSO	SV0005	BGSACSO2.	10/22/81	NA		10/21/81	BGSACSO81307.	11/3/81
SE	T.BGSE	SV0005	BGSACSE2.	10/22/81	NA		10/21/81	BGSACSE81307	11/3/81
GW	T.BGGW	SV0005	BGSACGW2.	10/22/81	NA		10/21/81	BGSACGW81307.	11/31/81
FD	FD.BG2	BG0003	BGSAGFD2.	10/30/81	11/12/81		11/16/81	BGSAGFD81320.	11/16/81
GS	GWSF.BG	BG0003	BGSACGS1.	10/30/81	11/3/81		11/3/81	BGSAGGS81320.	11/16/81
FD	FD.BGE	LX0001	FDBGE1.	12/28/81	12/30/81	12/30/81	12/30/81	BGSAGFD82005.	1/5/82
MA	MAP.BGE	LX0001	MAPBGE1.	12/28/81	NA		12/17/81	BGSAGMA81362.	12/28/81
GS	GS.BGE	PHONE	BGEGS1.	1/4/82	1/5/82	1/6/82	1/6/82	BGSAGGS82006.	1/6/82
CH	CH.BGE	BG0004	CHBGE.	2/17/82	NA		2/17/82	BGSACGW82064.	3/5/82

	COMMENTS
USA.BGSW.U	SURFACE WATER CHEMICAL ANALYSIS
USA.BGASH.U	CHEMICAL ANALYSIS ON ASH SAMPLES
MAP.BG	BLUEGRASS MAP FILE
MAP.BG2	MAP FILE FOR SURFACE WATER, SOIL, AND SEDIMENT
MAP.BG2GW	BLUEGRASS MAP FILE
T.BGSW	BLUEGRASS SURFACE WATER CHEMICAL DATA
T.BGSO	BLUEGRASS SOILS CHEMICAL DATA
T.BGSE	BLUEGRASS SEDIMENT CHEMICAL DATA
T.BGGW	BLUEGRASS GROUND WATER CHEMICAL DATA
FD.BG2	BLUEGRASS FIELD DRILLING #2
GWSF.BG	BLUEGRASS GROUND WATER STABILIZED FILE
FD.BGE	
MAP.BGE	
GS.BGE	
CH.BGE	CHEMICAL FILE FOR ONE WELL

Figure 6.3-1
EXAMPLE OF A MONTHLY DATA
FILE STATUS REPORT
SOURCE: ESE, 1987

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

data-checking routine is passed (if applicable), and when files are validated. A copy of the file status for an entire project will be included in the monthly Cost and Performance Report.

6.4 USATHAMA DATABASE MANAGEMENT SYSTEM OPERATION

The IR Data Management User's Guide (USATHAMA, 1984) furnished by the Data Management Staff of the Central Processing Site, Aberdeen, Maryland, provides the formatting requirements and field codes, as well as a listing of the software and hardware available to access the USATHAMA IR-DMS. The IR Data Management User's Guide specifies formatting for the possible data entries. A combination of programs developed by USATHAMA for the ESE Prime computer will be used for entering, checking, and formatting data into IR-DMS. As shown in Figure 6.1-1, IR-DMS receives data from the ESE data management system in which data have passed the required QC criteria.

According to the contract specifications, data will be transmitted to USATHAMA weekly. Data entering IR-DMS are input to the first level of a three-level system.

6.4.1 DATA FILE LEVEL STATUS CONTROL

The levels approach have been adopted by USATHAMA to clarify the status of data files. A Level 1 file is considered to be any data file that:

- Contains unvalidated data;
- Is not necessarily structured according to the formats outlined in this document; or
- Is a scratch file that a user might have.

Level 1 files are the sole responsibility of the originating user and will be processed immediately after verification of accurate transmission of the data to the USATHAMA computer. The Level 1 files will be deleted as soon as the data are elevated to Level 2. A maximum of 30 calendar days is allowed before the Level 1 data file is automatically deleted from storage by USATHAMA, in accordance with the IR-DMS policy of September 9, 1983.

All chemical data ' les are processed through USATHAMA's chemical data checking program. . is program checks for file format and content and rejects data not meeting all requirements. Rejected data are corrected and, if necessary, reviewed by the QA Supervisor and the LDC and then rechecked by the data-checking routine. When the files pass the data check, they will be upgraded to Level 2 by the ESE Data Management Supervisor. All files produced as a result of the USATHAMA data-checking routines will be deleted as soon as the data they contain have been transferred to Level 2.

Level 2 files are structured according to the formats outlined in the IR Data Management User's Guide. Records contained in Level 2 files may be accessed in the read-only mode by any user.

6.4.2 DATA FILES

Four types of data files are generated by field team activities: (1) the map file, (2) the field drilling file, (3) the ground water stabilized file, and (4) the well construction fil In addition, certain field sampling information must be . . d entered into the chemical data files.

Map File

The map file is a listing of the site ID's of the wells or other sampling sites, with the north and east coordinates in either State Planar or Universal Transverse Mercator, and the elevation in centimeters. The well sites are surveyed, and the coordinates are submitted by the task geologist to the LDC, who creates the well map file. A computer printout of the file is checked and validated by the QA Supervisor. All geotechnical and chemical files required a corresponding map file to be on record before data can be accepted and transferred to the USATHAMA computer. USATHAMA then upgrades the data to Level 2 status once all QC checks are processed.

Field Drilling File

The data for this file are taken from well drilling logs and include information on site identification (ID). date completed lithology. Soil

Classification System Codes, moisture, and depth. Once the field drilling data have been entered into a file and checked at the ESE Denver office, the data are sent to the Prime computer at ESE Gainesville. The LDC then submits the data to USATHAMA's IR-DMS in Level 1. Once the field drilling file is submitted to USATHAMA in Level 1, the data are checked with USATHAMA'S GEOTEST program, which checks for correspondence between sites in the map and field drilling files, accurate entry of data, and completeness in the field drilling file. Errors are printed out for correction in the Level 1 file. Validation takes place after GEOTEST is run error-free. After the ESE QA Supervisor has validated the field drilling and well map file, the data are elevated to Level 2.

Stabilized_Ground_Water_File

The ground water stabilized file is a compilation of static water levels in the wells at the time of sampling. It is submitted by the ESE Task Geologist after the sampling trip. The ground water stabilized file is submitted on IR-DMS forms and undergoes the same entry, checking, and validation procedures as the field drilling file, including checking with the GEOTEST program.

Well_Construction_File

The well construction file describes the actual monitor well construction and includes such information as Site ID, casing length, screen interval, stick-up, and seal. Like the field drilling file, this is compiled from bore logs by the RMA Site Geologist. The well construction file follows the same data entry, checking, validation, and transferral procedures as the field drilling file.

Chemical_Analysis_File

Field data which will be incorporated into chemical files are submitted within 10 days of sampling. This information includes sampling date, technique and depth, site and installation abbreviations, and sample type. It is submitted to the LDC and is verified in the data management system.

6.4.3 LOGGING OF TRANSMISSIONS

All attempts by the ESE Data Management Supervisor to transmit or manipulate data in the IR-DMS will be documented in a logbook at ESE. This log will contain:

- Date of attempt;
- Name of person making the call;
- Installation name;
- Work performed; and
- Problems encountered.

6.5 ROCKY MOUNTAIN ARSENAL INFORMATION CENTER (RIC)

The functions of the RIC include: (A) maintaining the hardcopy RMA data and document repository for the Installation Restoration (Contamination Control) Program; (B) working as an interface between the Environmental Division and the Manageme.. Information Systems Office of RMA for the purpose of maintaining a digital database on the RMA Harris computer for the Contamination Control Program; and (C) providing support to USATHAMA during the Shell litigation by updating the USATHAMA Installation Restoration Database and also by establishing a computerized information network based on IBM-PC compatible microcomputers.

A. Activities performed to maintain the document repository include:

1. Acquisition of n / materials including copies of reports, maps, technical papers, borelogs, well reports, etc. and computer printouts of physical and chemical data related to the RMA contamination control program.
2. Cataloging and filing of new material.
3. Providing assistance to RIC users in obtaining information. This assistance may take the form of document searching, obtaining material, recommending other resources, etc.
4. Material check-out and retrieval.
5. Creating monthly newsletters which include a listing of all hard copy information added to the RIC collection.
6. Production of yearly catalog of RIC holdings.

7. Maintaining RIC manuals and lists:
    a. Procedure manual;
    b. User's guide;
    c. Special holdings list;
    d. Authorized users' list;
    e. List of documents requested by date;
    f. Author/Organization common names list;
    g. Newsletter mailing list;
    h. For Official Use Only (FOUO) and Privileged Information document list and handling instruction;
    i. Interim report and deleted control number list;
    j. Map file list;
    k. Documents out as permanent copies list; and
    l. Photograph list.
8. Maintaining the RIC Satellite (duplicate information) Center located at USATHAMA.
9. Updating USATHAMA's bibliographic database.

B. Activities performed to maintain the Contamination Control Database include:
1. Data logging and coding.
2. Data entry:
    a. Hewlett-Packard to Tektronix procedure;
    b. Tektronix to Harris procedure; and
    c. Harris interactive procedures.
3. Data verification and editing to assure that data is correct in content and format is entered into the database.
4. Updating the RMA Contamination Control Database on the Harris system.
5. Serving as an interface between the Environmental Division and the Management Information Systems Office of the RMA to establish and maintain the RMA Contamination Control Database on the Harris 530 minicomputer.

6. Serving as an interface between RMA and USATHAMA in the maintenance of the Installation Restoration Database on the USATHAMA computer.
7. Data retrieval and report production using COBOL programs and the query language on the Harris computer.
8. Providing guidance to database users on defining needs and applying available software routines.
9. Preparation of formal and publishable reports consisting of graphs, charts, computer plots, narrative, etc. needed to support contamination control programs.
10. Providing contamination control related statistical support to all branches and office within the Environmental Division. Support includes both descriptive and inferential statistics along with computer produced reports, tables, and summaries. Typical tasks include the design and analysis of experiments, analysis of variance, and guidance in statistical quality control.
11. Production and updating of "cookbook" style user guide for the Contamination Control Database.
12. Assist Automated Systems Office physical scientist with development of BASIC and FORTRAN programs for analytical, quality control, and sample management tasks which support the RMA contamination control programs.
13. Production of monthly report of PIC activities and all actions affecting database development and maintenance.

C. Activities to support USATHAMA during litigation include:
   1. Providing USATHAMA with computer tapes containing data updates from the RMA Contamination Control Database.
   2. Providing USATHAMA personnel, contractors, and other individuals involved in the litigation with data printouts, reports, summaries, etc. from both the USATHAMA and RMA data systems.

3. Establishing a microcomputer information network based on IBM-PC compatible hardware. This information network will be designed primarily to aid in the communication between organizations responsible for responding to the interrogatories from the litigation.

Services to be provided include:

a. Word processing;

b. Electronic mail and data sharing via computer/modem communication;

c. Computerized RIC document cross-referencing;

d. Creating of DBase III programs to produce miscellaneous project management reports; and

e. Development of computer programs for the IBM-PC and corresponding user manuals and instruction.

7.0 SAFETY PROGRAM

The purpose of this section is to summarize the safety, accident, and fire protection standards, and to outline standard operating procedures to ensure the safety of all ESE and subcontractor personnel performing Task 44 activities at RMA. Responsibilities, authorities, and reporting procedures as designated for Task 44 are identical to those designed for Task 1 in Section 7.0 of the Task 1 Technical Plan.

The program addresses all of the requirement of DI-A-5239B and fully complies with requirements of the Occupational Safety and Health Administration (OSHA) and U.S. Army Material Command (AMC) Regulation 385-100, Army Regulation (AR) 385-10, and Department of Army Pamphlet (DA PAM) 385-1 for all activities to be conducted. The program also complies with the ESE Analytical Laboratory Safety Plan.

7.1 TASK 44 PROCEDURES

7.1.1 WASTE CHARACTERISTICS

In the 43 year history of RMA, many hazardous substances have been manufactured, stored, or demilitarized at the post. Key compounds include GB and other nerve agents, H and L blister agents, munitions, organochlorine pesticides and herbicides, phosgene, hydrazine, and toxic metals. Detailed information on many of these compounds is provided in Agent Fact Sheet, SMCRM Form 357 (RMA, 1984) and Military Chemistry and Chemical Agents, TM 3-215 and AFM 355-7 (U.S. Departments of Army and Air Force, 1963, RIC#84221R01). Copies of this information are available at the support trailer at RMA.

7.1.2 GENERAL PROCEDURES

As Task 44 activities will be RMA wide, the program will be conducted in both uncontaminated and contaminated areas. In order to develop the most adequate Safety Plan possible, an evaluation of each sampling and monitoring station will be made. This will result in each sampling and monitoring location being treated separately. Overall procedures and methods are outlined in the following sections.

An area of 30 ft will be established around all wells and surface monitoring/sampling sites. This will be considered a "hot zone" and all personnel entering this area will wear the prescribed level of protection. Before entering the "hot zone" all personal protective equipment will be checked for proper fit and operation.

In areas of known or suspected contamination the following decontamination procedures will be followed:

- Equipment decontamination will occur at the sampling site. Bailers, pumps, and other field equipment will be washed at the hotline using trisodium phosphate and water followed by a triple rinse with distilled water, and wrapped in a plastic bag.
- Field team members will have a two-phase decontamination procedure. Outer clothing will be rinsed at the hot line. After this initial decontamination, field personnel will ride in the truck to the decontamination pad. At the pad, all disposable clothing will be removed and discarded into barrels. The field personnel will then ride into the support area, enter the field wash trailer, shower, and change into street clothes.

To avoid contaminating the vehicle, the seats and floors will be lined with plastic at the beginning of each day and after lunch. When field personnel decontaminate at the decontamination pad, this plastic will be removed and discarded. The truck will then be considered clean.

When sampling wells and surface water and taking water level measurements in Section 36, the truck will be considered contaminated. The vehicle will then be decontaminated at the decontamination pad in Section 36 using the hot water pressure washer.

7.1.3 SURFACE WATER SAMPLING

Surface water within the boundaries of RMA will be sampled during Task 44. The major hazards during this activities are skin and eye contact with

contaminated water as well as physically falling into a body of water. As all surface water sampling will be done from the edge of the water body and not from a boat, the falling hazards should be minimal.

Levels of protection for the surface water sampling/monitoring portion of Task 44 are based on an evaluation of the respective locations by the Subtask Supervisor.

- Section 36--Field personnel will wear modified Level D protection while performing surface water sampling/monitoring in Section 36. Respirators will be readily available and equipped with Scott 642 OV-H cartridges. Saranex-coated Tyvek coveralls will be worn while conducting operations. Personnel will monitor the area with a photoionization detector to determine airborne organic vapor concentrations.
- Other areas--Field personnel will wear level D protection at all other sampling monitoring sites. Protection will consist of inner and outer rubber gloves, steel toe and shank rubber boots, goggles for eye protection, and cotton overalls. Respirators will be readily available.

All sampling and monitoring efforts will be performed in teams of two. Before commencing activities, field personnel will check in at the safety trailer. While wearing Level D protection, samplers will avoid submerging their hands in water so deeply that water drains into the top of the gloves. Gloves should be taped at the wrists in modified Level D protection. Levels of protection will be upgraded if the Safety Officer deems necessary.

7.1.4 GROUND WATER SAMPLING

Ground water from existing wells on RMA will be sampled by field team members. As with surface water sampling, skin and eye contact with contaminated water is a major hazard. Inhalation hazards are increased when the well is first uncapped due to a possible buildup in the well of hazardous vapors, and during well purging as volatile may be stripped from the water and become airborne.

Continuous monitoring with a photoionization detector will take place during well uncapping and purging activities. Field personnel will uncap wells from the upwind side. Level C protection will be worn during uncapping activities. If an above background reading is detected during opening, team members will remain in Level C protection for the completion of well sampling.

If organic vapor concentrations are detected above background in the breathing zone during well sampling, respirators will be worn at all times or until the Safety Officer states that respirators may be removed. During both uncapping and pumping activities, if organic vapors are detected above 5 ppm in the breathing zone, work activities will cease immediately and team members will don Level B protection to complete the well sampling.

Levels of protection for the ground water sampling portion of Task 44 will be based on an evaluation of the respective sampling sites by the Subtask Supervisor or representative. However, face shields will be worn at all times when field personnel are handling water or during bailing and pumping activities. In general, modified Level D protection in the uncontaminated areas and full Level C or B protection in contaminated areas will be required. Levels will be adjusted as the Safety Officer deems necessary based on organic vapor levels and well history. During ground water sampling, field teams will consist of at least two persons. A first aid kit and fire extinguisher will be available at all times. Sampling teams will check in at the safety trailer prior to commencing activities.

7.1.5 WATER LEVEL MEASUREMENTS

Field personnel performing water level measurements will don Level D protection to complete their activities unless they are entering Section 36. Respirators will be readily available. Personnel will uncap well while wearing respirators as outlined in Section 7.1.4. The field team will continuously monitor for organic vapors using a photoionization detector. Personal and respiratory protection may be modified based on organic vapor readings and well history.

7.2 CONTINGENCY PLANS

7.2.1 CHEMICAL AGENTS

According to information supplied by the RMA laboratory, chemical agents readily breakdown when in contact with water. Due to this fact, field personnel should not contact chemical agents during their water sampling activities. Thus, no additional monitoring for agents will be necessary. Safety procedures regarding unexploded ordnance (UXO), emergency services, fires/spills, and accident reporting are detailed in Section 7.0 of the Task 1 Technical Plan.

8.0 CONTAMINATION ASSESSMENT

The Contamination Assessment efforts will integrate and interpret all data generated during the environmental monitoring, sampling, and analysis phases of the program. The assessment will include, at · minimum:

- o Contamination plume and water table maps and evaluations for each sampling period;
- o Assessment of any changes from previous data and recommendations for installation or omission of wells for better and more efficient monitoring;
- o A thorough evaluation of the levels of contamination in both the Denver and Alluvial aquifers;
- o An assessment of how ground water contamination may be migrating throughout the area investigated (i.e., onpost and offpost);
- o Stratigraphic/hydrogeologic evaluation of the alluvium and Denver Formation to identify geometry, extent, and potential for hydraulic interaction of aquifer units; and
- o Compilation of hydrologic data produced by other RMA tasks; and

Data requirements of the EA and FS groups will be addressed and, when appropriate, Task 44 will provide interpretive efforts in the areas of geology and hydrology to aid them in achieving specific goals. Comparisons to historical results and applicable standards will be performed in order to evaluate potential effects on public health and the environment.

8.1 GROUND WATER

Interpretation of contaminant migration patterns in ground water will require the analysis of the hydrologic and chemical data collected during the field program. The interpretive effort will be enhanced by evaluations of site hydrology and geology, previously generated hydrologic and chemical data, contaminant characteristics, applicable standards and criteria, and the nature of potential contaminant source areas.

Evaluation of hydraulic conditions will begin with computer posting and hand contouring of water level data. The water level network will be divided into alluvial and Denver components. The Denver monitoring network will be further subdivided by completion interval into those wells representing significant individual sand units within the Denver Formation. Consideration of the hydrology of individual sands will provide a mechanism to evaluate potential interconnection of the Denver Formation with the overlying alluvium through faults, fractures, permeable subcrop areas, or leaky aquitards. The result of this evaluation will be a vertical series of potentiometric surfaces for primary transmissive units in the alluvium and Denver Formation. Comparison of these potentiometric surfaces through calculations of differential head maps will allow determination of hydraulic gradients and the relative significance of vertical and lateral flow. Determination of ground water flow rates and volumes may be performed in an appropriate manner through the use of graphical solutions such as flow nets in conjunction with transmissivity values estimated from existing aquifer test data and sedimentologic characteristics. Alternatively, the potentiometric data may be used to calibrate or verify more sophisticated numerical models developed under other programs.

In addition to comparison of potentiometric data between transmissive aquifer units, Task 44 water level data will also be compared to historical records. This comparison will be conducted to provide information to FS programs, as monitoring of water levels in areas of remediation will be required to determine the correct functioning of ground water treatment systems as well as inadvertent modifications to the ground water flow system.

Chemical sampling results will also be evaluated to identify potential deviations from previously observed contaminant levels. Data generated during past monitoring efforts will be compared to current monitoring program results, and ranges of previously observed contaminant concentrations will be tabulated for each well in the monitoring program. These existing data, which will be compiled and entered in the ESE computer network, will provide a representation of baseline conditions to compare with long-term monitoring data. Comparisons between historical

(pre-Task 44) and Task 44 data will be conducted to identify any contaminant concentration variation trends. These evaluations will be largely automated, providing ESE with preliminary comparisons as analytical data become available. Review of these comparisons may provide a timely mechanism to alert the project team to potential problems related to site remediation activities. Identification of these potential problems will also allow early definition of conditions that may pose an imminent risk to public health or the environment.

Ground water contaminant plume maps will also be generated to identify major contaminant pathways in both alluvial and Denver aquifers. Analytical data for selected individual contaminants or groups of similar contaminants will be organized by aquifer unit and posted in appropriate locations using computer mapping techniques.

The wells in the chemical sampling network will be separated into alluvial and Denver sand components. Analytical results from these potential aquifer units will be plotted and contoured individually, allowing a comparison of contaminant migration patterns in successively deeper transmissive units. Evaluation of contamination patterns in both the alluvial aquifer and the underlying bedrock formation is required for design of ground water remediation system and for monitoring the effects of soil, sewer, and building remediation activities. Contaminant plumes will be compared to previously observed configurations, and changes in spatial distribution identified. The significance of changes in plume configuration will be evaluated with respect to site remediation activities and identified contaminant source areas.

As site remediation activities progress and monitoring objectives evolve, modification of the monitoring well network may be necessary. Modifications may require addition, deletion, or substitution of existing wells in order to adequately monitor changing site conditions. Additional wells may also be added to the program to fill particular data needs, such as monitoring of active remediation systems. Selection of existing wells or planning of new wells will require careful evaluation of site hydrology, geology, and geochemistry, as well as formulation of objectives for the revised program.

Ongoing compilation, reduction, and evaluation of the chemical and hydrologic data generated during the long-term monitoring program will permit an adequate review of proposed alternatives for future monitoring.

8.2 SURFACE WATER

The surface water data collected in the scheduled sampling program must be collated and analyzed to show how the surface water flows through RMA and what contaminants, if any, are being transported as a result of the surface water flows. Relationships between ground water levels and surface water flows may also be developed utilizing both surface water and ground water data.

Data derived from the stream gaging program are the continuous stage records taken at the gaging stations during the nonfreezing operations season. These data must be converted into hourly flow data, utilizing either a rating equation or a developed rating curve. The hourly data are then averaged to provide a daily flow which is converted to acre-feet per day. These data in turn can be summed over a particular time period.

The hydrographs obtained at the various stream-gaging locations will be analyzed on a selected basis to determine base flow, interflow (if any), and surficial runoff components. This will be accomplished using standard hydrograph separation techniques. This information will then be utilized in analyzing the surface water quality data with respect to surface water and ground water components.

Lake stages are planned to be read weekly or more often, if conditions warrant. The volumes of the lakes have been related to the stage through stage-volume curves. These curves are initially developed from the topographic contours of the bottom of the lake or pond. Existing curves are available for Upper Derby, Lower Derby, and Ladora Lakes. A survey was conducted for Havana Pond in 1986 and the Ladora stage-volume data were reanalyzed at the same time to remove apparent discrepancies.

The flow data and the lake data are then utilized along with the precipitation, evaporation, and estimated transpiration data to compute a

water balance for the select areas of RMA. The resulting water budget will be used to determine potential gains to or losses from the shallow ground water system. Understanding of these interactions is useful for evaluation of contaminant transport pathways and design of ground and surface water remediation systems.

Surface water quality samples will be evaluated to assess actual and potential surface water contaminant transport in a manner that produces a better understanding of the RMA-wide contaminant migration mechanisms and allows remediation work to be planned. Any degradation in surface water quality will be characterized and quantified. Observed contaminant concentrations will be compared to applicable standards, regulations, and guidance levels.

In addition to the regular sampling plan, notes will be made of any special conditions noted in the surface waters. This would include such items as oil slicks, water discoloration, and products washed onto RMA. These have been noted at times during this past year on the Peoria Interceptor and, at times, in the Havana Pond. Information on upgradient degradation of water quality may prove to be particularly helpful in the analysis and understanding of contaminant transport and development of remediation planning.

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APPENDIX A
COMMENTS AND RESPONSES TO THE DRAFT FINAL TECHNICAL PLAN, NOVEMBER 1987

APPENDIX A

COMMENTS AND RESPONSES TO THE DRAFT FINAL TECHNICAL PLAN, NOVEMBER 1987

Memorandum of Agreement (MOA) written comments on the Task 44 Draft Final Letter Technical Plan were received from MOA parties on June 22, 1987 (Shell Oil Company), August 7, 1987 (Colorado Department of Health), and August 28, 1987 (U.S. Environmental Protection Agency). MOA general comments to the Task 44 Draft Final Technical Plan were discussed in the MOA meeting of November 16, 1987. Written comments on the Task 44 Draft Final Technical Plan were received from Shell Oil Company on December 16, 1987 and responses are provided in Appendix A of this Technical Plan. No verbal or written comments were received within the review period from CDH or the EPA after submittal of the Task 44 Draft Final Technical Plan. Should comments be received at a later date, an addendum with responses will be issued.

The Task 44 Final Letter Technical Plan was distributed to the MOA parties on February 11, 1988. Comments and response to the Draft Final Letter Technical Plan were incorporated as Appendix A to that final document. It is requested that this previously submitted Final Letter Technical Plan be incorporated as Appendix B in this Final Technical Plan to complete this document.

Shell Oil Company

One Shell Plaza
P.O. Box 2463
Houston, Texas 77252

December 16, 1987

USATHAMA
Office of the Program Manager
Rocky Mountain Arsenal Contamination Cleanup
ATTN: AMXRM-EE: Chief: Mr. Donald L. Campbell
Bldg. E4460
Aberdeen Proving Ground, MD 21010-5401

Dear Mr. Campbell:

This letter is reference to your Draft Final Technical Plan for Task 44: On/Offpost Groundwater/Surface Water Monitoring Program. Please recall that we submitted detailed comments on the Task 44 Draft Final Letter Technical Plan on June 22, 1987. Also, at a meeting attended by the parties on November 16, we provided you with additional comments on revisions to the fourth quarter sampling network. We trust you will consider and implement all of the above comments in your future work. We understand that some of these revisions may be incorporated in the forthcoming Comprehensive Monitoring Program.

Sincerely,

C. K. Hahn

C. K. Hahn
Manager
Denver Site Project

WEA:ajg

cc: (w/enclosure)
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DEPARTMENT OF THE ARMY

PROGRAM MANAGER FOR ROCKY MOUNTAIN ARSENAL CONTAMINATION CLEANUP

ABERDEEN PROVING GROUND, MARYLAND 21010-5401

REPLY TO ATTENTION OF

March 10, 1988

Remedial Planning Division

Mr. Chris Hahn
Shell Oil Company
c/o Holme Roberts and Owen
1700 Broadway
Suite 1800
Denver, Colorado 80290

Dear Mr. Hahn:

We appreciate your comments on the Draft Final Technical Plan for Task 44 - On/Offpost Ground/Surface Water Monitoring Program, contained in your letter of December 16, 1987. We acknowledge that you submitted detailed comments on the Task 44 Draft Final Letter Technical Plan on June 22, 1987. We also acknowledge that you provided verbal comments on the revision to the fourth quarter FY 1986 sampling network at a meeting on November 16, 1987. These comments have been considered and included as appropriate in the Draft Final Technical Plan. Your comments will also be included as appropriate to future ground/surface water monitoring programs.

If you have any questions or comments contact Mr. Darrel Smith, this Office, (301) 671-3261.

Sincerely,

fa Donald Campbell
Technical Director

Copies Furnished:

Department of the Army, Office of the Judge Advocate General, Attention: Lieutenant Colonel Scott Isaacson, Washington, D.C. 20310-2200
Mr. David Anderson, Department of Justice, Environmental Enforcement Section, Land and Natural Resources Division, P.O. Box 7415, Benjamin Franklin Station, Washington, D.C. 20044-7415
Mr. William Adcock, Shell Oil Company, 1 Shell Plaza, 900 Louisiana Street, Room 1316, Houston, Texas 77210
Mr. Edward McGrath, Holme Roberts and Owen, 1700 Broadway, Denver, Colorado 80290
Mr. Glen Rasmussen, Morrison-Knudsen Engineering, Inc., 1700 Broadway, Suite 1600, Denver, Colorado 80290
Ms. Dana Scott, D.P. Associates, Inc., Building E4581, Beal Road, Aberdeen Proving Ground, Maryland 21010-5401

APPENDIX B
TASK 44 FINAL LETTER TECHNICAL PLAN,
FEBRUARY 10, 1988 AND COMMENTS AND RESPONSES
TO THE DRAFT FINAL LETTER TECHNICAL PLAN, APRIL 19, 1987

LITIGATION TECHNICAL SUPPORT AND SERVICES

Rocky Mountain Arsenal

Water Quantity/Quality Survey

Letter Technical Plan - Ground Water Monitoring Well Network
February 10, 1988
Contract No. DAAK11-84-D-0016
Task No. 44

PREPARED BY:

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.
Harding Lawson Associates

PREPARED FOR:

U.S. ARMY TOXIC AND HAZARDOUS MATERIALS AGENCY

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I. INTRODUCTION

This Letter Technical Plan was prepared under Rocky Mountain Arsenal (RMA) Task Order Contract, Delivery Order No. 44. The purpose of Task 44 is to design a long-term monitoring network and implement regional ground-water and surface-water monitoring in both the on-post and off-post areas. Due to the required task schedule, and to provide continuity with the previous year of regional ground-water monitoring (Task 4), it was determined that ground-water sampling activities should begin as soon as possible following award of Task 44. The purpose of this Letter Technical Plan is to present the criteria and rationale utilized to select the ground-water monitoring well network. A complete Task 44 Technical Plan which addresses all aspects of the regional ground-water and surface-water monitoring program will follow at a later date.

The regional Task 44 program provides coordination between other site specific ground-water tasks. Data from these local ground-water tasks will be incorporated into Task 44 and its successor.

A. Current and Future Ground-Water Programs

This Letter Technical Plan presents the well network design for Task Order No. 44 which deals with regional ground-water monitoring for both on- and off-post areas. However, five other current and future ground-water tasks are in various stages of data collection or development. These five additional tasks are ground-water studies dealing with specific investigative areas such as the boundary systems, primary potential sites, and/or potential migration pathways (Figure 1). Data generated by these area specific tasks will be used to assess contaminant distribution in the

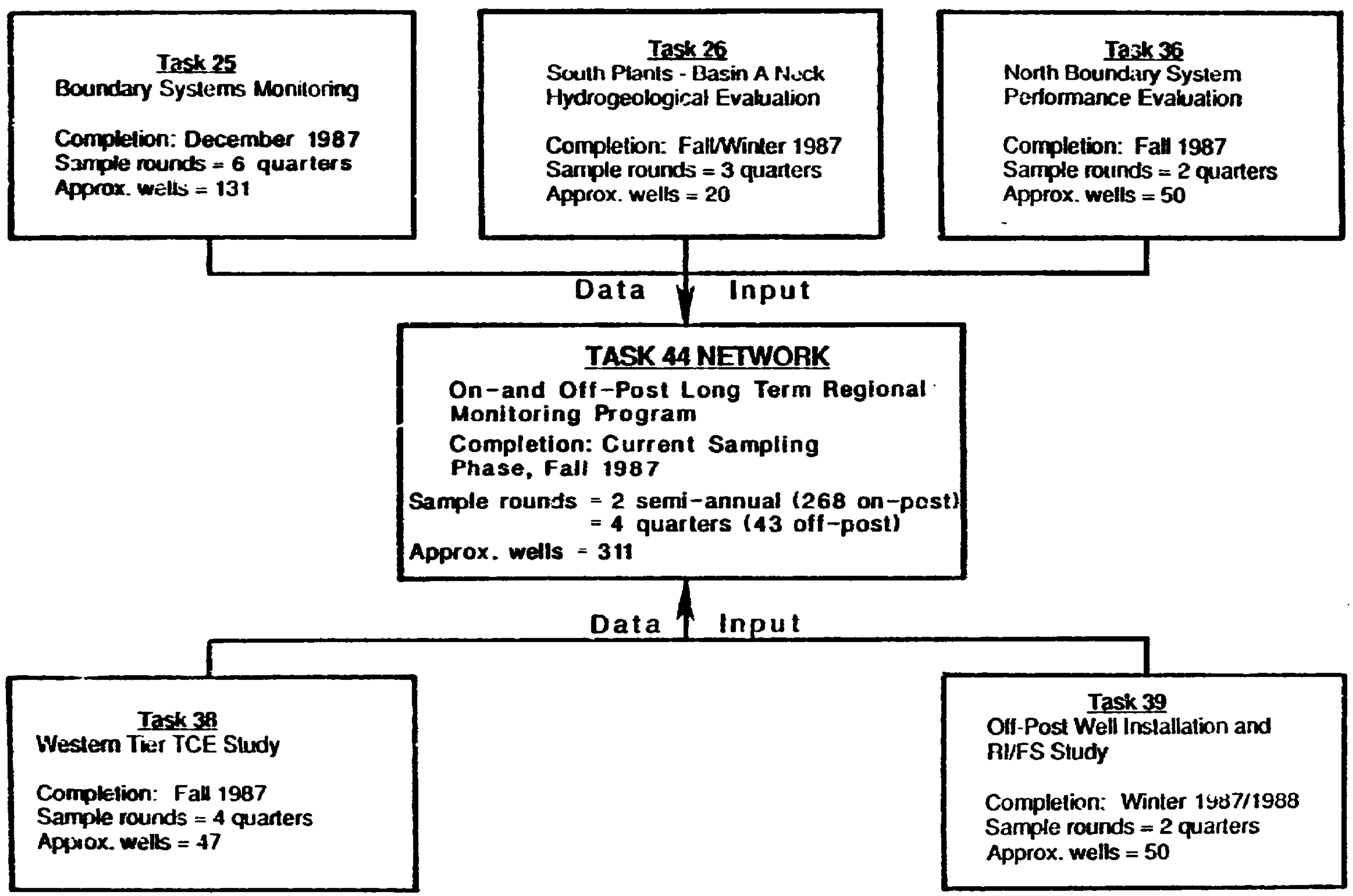


Figure 1
DETAILED GROUND WATER STUDIES AND THEIR RELATIONSHIP TO TASK 44
SOURCE: HLA, 1987

Prepared for:
U.S. Army Program Manager's Office For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

regional ground-water system. Data from these five tasks will provide a more detailed level of understanding in a specific area than will a regional program such as Task 44.

Coordination of all ground water related tasks is necessary to provide for integration and interpretation of all relevant data and to eliminate possible duplication of effort. The five area specific ground-water tasks may be viewed as subsets of the more regional Task 44 program. These tasks will be designed, executed, and completed to achieve specific objectives. Task 44 will provide the regional framework under which such tasks will be operated. One of the goals of Task 44 is to incorporate data from and provide input to the current and future site specific ground-water tasks.

Task 4 provided a basic sampling network on which to build the Task 44 program. Task 44 will provide for integration and interpretation of geologic, hydrologic, and geochemical data to refine the current understanding of the distribution of contaminants at RMA. Although Task 44 is only a one-year program, successor programs will maintain the regional monitoring network developed as part of Task 44.

B. Objectives of Task 44

The purpose of Task 44, as described in the Delivery Order for the task, is to provide regional monitoring of both on-post and off-post ground water and surface water. The objectives of this task, as specified by the Delivery Order are to:

1. Assess the distribution and concentration levels of ground-water contaminants, and monitor changes in water quality with respect to these contaminants for both the on-post and off-post areas.

2. Monitor and evaluate changes in water levels (875 wells).

3. Evaluate data and recommend program modifications to this or other ground-water monitoring tasks.

4. Identify areas of significant public health exposure.

Although these four objectives were presented in the Delivery Order for Task 44, there are several other task objectives that are either inferred by these four basic objectives or implied in the text of the Delivery Order. The presentation and review of these other objectives should more clearly define the scope of work for Task 44. These additional objectives are to:

5. Utilize available geologic data to provide a description of the geologic conditions.

6. Use available hydrologic and water quality data in conjunction with geologic interpretations to describe the hydrogeologic conditions in the on-post and off-post areas.

7. Assess the distribution of contaminants in aqueous media and identify the pathways by which these contaminants are being transported to the RMA boundary or the off-post area.

8. Assess the relationship of sites where potential soil contamination exists to the presence of contaminants in ground-water or surface-water systems.

9. Integrate all ground-water related tasks.

The above objectives will provide personnel working with the RMA Endangerment Assessment (EA) and Feasibility Study (FS) groups with a characterization of contaminant hydrogeology and provide a mechanism for identifying and filling data deficiencies through installation and sampling of new monitoring wells. Therefore, for these groups to accomplish their objectives, this investigation must be comprehensive in nature and provide

adequate interpretation of geologic, hydrologic, and geochemical data to assess public health and environmental impacts and also to evaluate candidate remedial alternatives.

C. Purpose and Scope of Letter Technical Plan

As stated previously, the purpose of this Letter Technical Plan is to discuss the criteria established and rationale used to design the ground-water monitoring well network for Task 44 sampling. This Letter Technical Plan was prepared in advance of the Task 44 Technical Plan to allow review of the network design prior to implementation of sampling.

In order to design the Task 44 network the following scope of work was performed. Borehole logs and cross sections were examined to establish a preliminary evaluation of subsurface geology. Water level data, from the Task 4 program, were examined to establish directions of ground-water flow within the alluvium and aid in the correlation of the permeable units within the Denver Formation. Water quality information from the Task 4 program and, as appropriate, from the historical data base were examined to formulate an assessment of the distribution of contaminants within the RMA ground-water system. These assessments are not complete; however, they will be modified as additional information is obtained and interpreted. A preliminary assessment of hydrogeologic conditions was used to design the proposed Task 44 well network. In addition to the design of the network, this Letter Technical Plan presents the suite of target compounds for which every sample collected during the first semi-annual sampling will be analyzed.

II. OFF-POST MONITORING NETWORK

The off-post monitoring network will consist of 43 wells from Task 6 (Contract No. DAAK11-83-D-007) as listed in Table 1 and shown in Figure 2. Well selection criteria were not evaluated in depth for off-post wells because these wells were taken directly from Revision III of the 360 degree monitoring program. Of the 43 total off-post wells, 42 are completed in alluvium and one is considered a Denver Formation well. Off-post and on-post wells will be sampled and the water analyzed using identical procedures except that off-post wells will be sampled quarterly as compared to the semi-annual on-post program. Additional monitoring of the Denver Formation will be performed under Tasks 25, 26, 36, and 39. These tasks also include installation of Denver Formation monitoring wells in selected locations.

III. ON-POST MONITORING WELL NETWORK DESIGN

The ground-water quality monitoring network for long-term monitoring at RMA (Task 44) was selected from over 1500 wells. The network was designed to use existing wells to assess and monitor the areal and vertical distribution of ground-water contamination in the alluvial and Denver Formation aquifer units in both on-post and off-post areas. In addition, network monitoring will provide hydrochemical and hydraulic data for evaluating probable contaminant migration pathways and to identify areas that require additional monitoring. A map of the on-post area is presented in Figure 3 showing major potential contaminant sites, cultural features, and boundary containment systems.

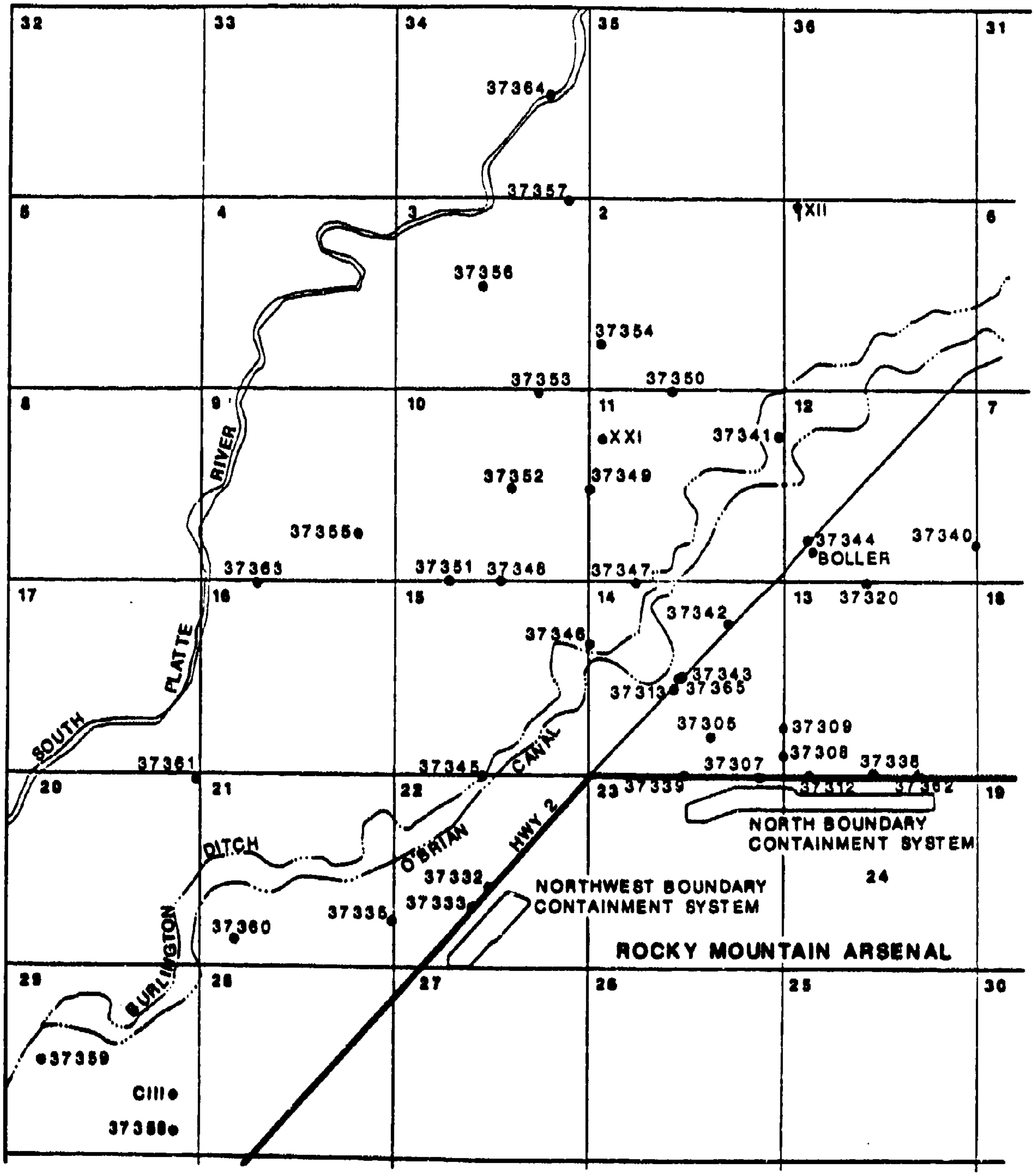
Table 1: Task 44 Off-Post Well Network

37305*	37348
37307	37349
37308	37350
37309	37351
37312	37352
37313	37353
37320	37354
37332	37355
37333	37356
37335	37357
37338	37358
37339	37359
37340	37360
37341	37361
37342	37362
37343	37363
37344	37364
37345	37365**
37346	37366
37347	

Also included are the following four alluvial domestic wells:

Boller
XII
XXI
CIII

*Well to be abandoned.
**Denver Formation well.



Note: Off-Post Well 37366 is Southeast of RMA, See Figures 7, 8, and 9 37365 Denver Formation Well

Figure 2
PROPOSED OFF-POST TASK 44 ALLUVIAL AND DENVER WELL MONITORING NETWORK

SOURCE: HLA, 1987

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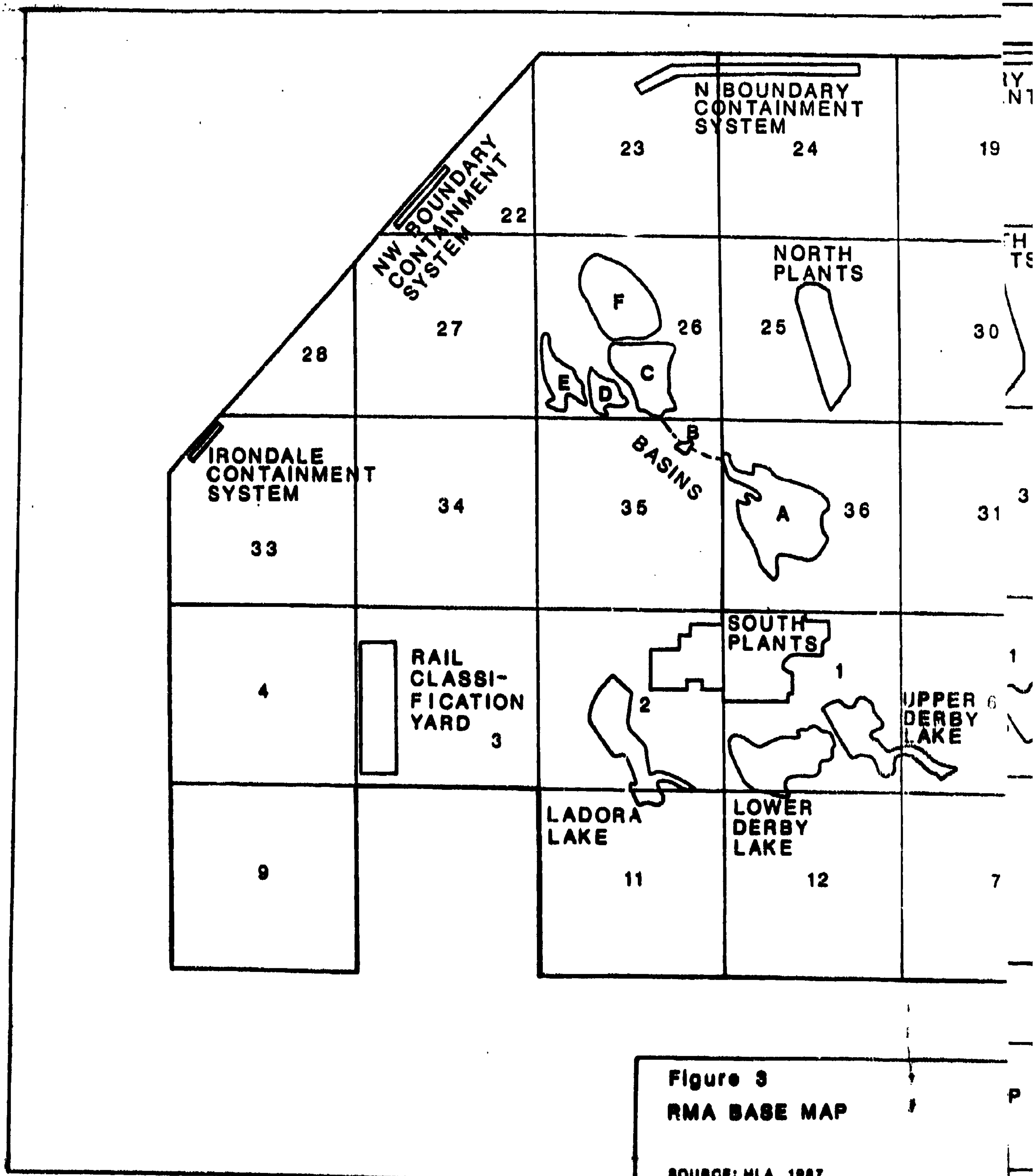

Figure 3
RMA BASE MAP

SOURCE: HLA, 1987

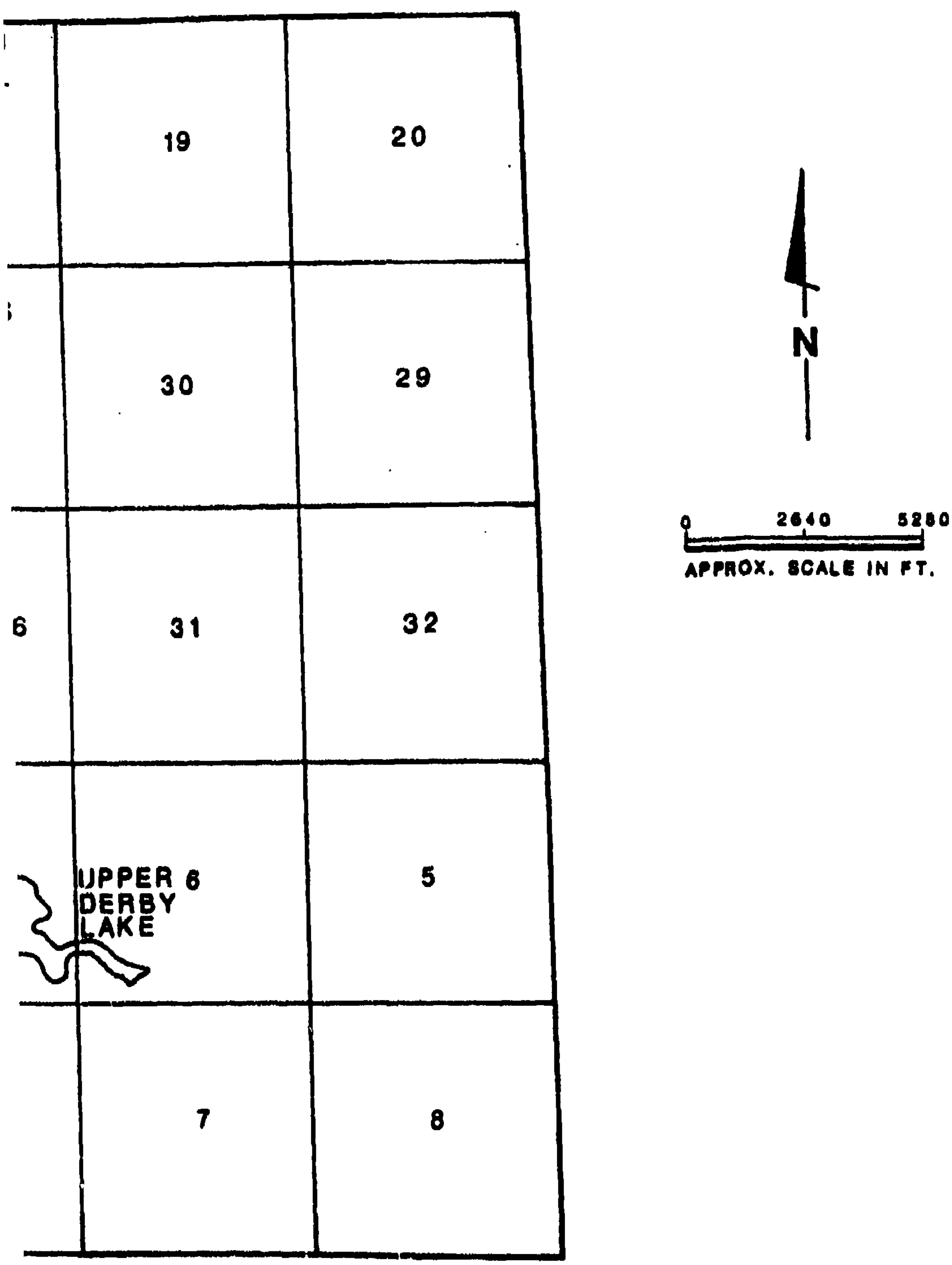

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Figure 3

Information regarding the conditions of monitoring wells and their sampling history was obtained from historical data and the design and implementation of other RMA tasks, including Tasks 4 (Regional), 25 (Boundary Systems), and 38 (Western Tier). Although Task 44 provides for the long-term monitoring network, wells were not removed from consideration solely on the basis of their inclusion in the monitoring network for another task. Task 44 is the regional framework for water quality monitoring and, therefore, other current ground-water monitoring networks will be modified to consider the Task 44 network and to avoid duplication.

Wells were selected for inclusion in the Task 44 monitoring network based on three classes of criteria:

1. Common well characteristics.
2. Alluvial well specifics.
3. Denver Formation well specifics.

Based on these criteria, each well was identified for possible inclusion in the network and was assigned a priority ranking. The final monitoring network was then selected from the ranked wells to provide a network that will best accomplish the objectives of Task 44.

A. <u>General Well Selection Criteria</u>

Criteria used to select wells for inclusion in the monitoring network that were common to both the alluvium and the Denver Formation included:

- Quality of well construction.
- Current condition of the well.
- Historical water-quality data.

- Well location with respect to known areas of degraded water quality and potential contaminant sites.

- The presence or absence of adjacent wells completed in different hydrologic zones (well clusters).

- The geologic and hydrologic conditions in the vicinity of the well.

The well construction evaluation utilized groupings developed during the Task 4 program (ESE, 1986). During Task 4, wells were classified as acceptable, potentially acceptable, questionable, or unacceptable based on well construction data that were then available. These terminologies were assigned largely on the presence or absence of supporting documentation. The ratings are, therefore, not meant to infer that a "questionable" designation is a well of questionable construction, but that insufficient data was obtained to assign a higher rating. Some wells were reclassified during design of this network because data (e.g., boring logs or well completion diagrams) were located subsequent to Task 4. These data were then utilized in reevaluating wells that were previously classed as questionable or unacceptable due to the absence of geologic and/or well construction data. As a result of recent investigative activities, new ground-water monitoring wells have been installed since the Task 4 sampling effort. When possible, these newly constructed wells were also considered for the program. Newly installed monitoring wells will be considered for inclusion into the Task 44 network following installation, development, and two sampling events.

The current condition of each well was evaluated with respect to sampling. Through this evaluation, such factors as constrictions in wells or wells yielding low volumes of water were considered. Wells that had

been abandoned or destroyed were also identified. However, other criteria such as the water quality history associated with these destroyed wells and the location of the wells with respect to known contaminant sites was investigated. If no wells currently exist within an area to be monitored then recommendations for new well installations were made to augment the Task 44 network. All recommendations for new wells that are generated by all ground-water related tasks are coordinated through the Composite Well Program. This program rates and assigns priorities for installation of all new wells in both the on-post and off-post areas.

The historical water quality data obtained from each well were evaluated with respect to the guidance levels developed for off-post water quality. These guidance levels are based on existing regulatory criteria, or where such criteria were not available, on preliminary concentrations developed by the U.S. Army and thought to be acceptable to appropriate state and federal aencies. Where chemical concentrations did not exceed these guidance levels, water quality degradation was generally considered to be less significant.

The water quality guidance levels are not necessarily identical to the final action levels to be used in selecting one or more remedial actions for ground water. Action levels are currently being developed as part of the endangerment assessment (EA) process. As part of this process, the Program Manager will determine whether action levels for certain chemicals must be based on applicable or relevant and appropriate standards (ARARs) established by state or federal agencies for those chemicals. In many

cases it is anticipated that action levels will be identical to, or at least within the same order of magnitude of, the guidance levels used in Task 44.

Historical water quality data for each well were evaluated based on the period of record, sampling frequency, consistency of results, and probable quality of laboratory and field quality assurance and quality control data. In general, recent water-quality data, such as that derived from Task 4, were thought to be the most reliable and were given highest consideration. Wells with consistent chemical results were generally considered more reliable than those with inconsistent results except when sporadic results could have been obtained as a result of fluctuating ground and surface water conditions. Alternatively, inconsistent results may occur when concentrations are at or near the detection limit of the analytical method.

The well location with respect to known areas of water quality degradation or potential contaminant sites was considered in two ways. First, wells near contaminant sites were emphasized to track the extent of vertical and horizontal contaminant migration. Second, for areas where several wells from Task 4 exist and data from these wells provide essentially the same information, a single Task 4 well was recommended for sampling under Task 44 in order to eliminate data duplication.

Wells were also evaluated on the basis of the presence of adjacent wells completed in different vertical intervals. Groups of adjacent wells, or well clusters, were emphasized in order to provide information on vertical chemical distributions and hydraulic gradients. Through this kind

of assessment, it is possible to evaluate the potential for vertical contaminant migration. When considering clustered wells screened within Denver Formation sand units, historical water-quality data was used to select the well or wells to be monitored. Where the deepest Denver interval sampled contained contaminants above guidance levels, this well was included in the network and recommendations made for a deeper well at that location. At well cluster sites where there is a decrease in contaminant concentrations with depth, wells containing contaminant levels below guidance criteria were generally not included in the network unless geologic or hydrologic conditions suggested otherwise.

Geologic and hydrologic conditions in the vicinity of the wells were considered in order to evaluate the possible hydraulic communication between areas. The local horizontal flow direction was considered in conjunction with the monitored interval in each well. For example, a contaminated well in a shallow Denver Formation sand unit would indicate that sampling a downgradient well in a similar sand unit may be more desirable than other sand units in order to track potential downgradient contaminant migration.

B. Criteria Specific to the Alluvial Monitoring Network Design

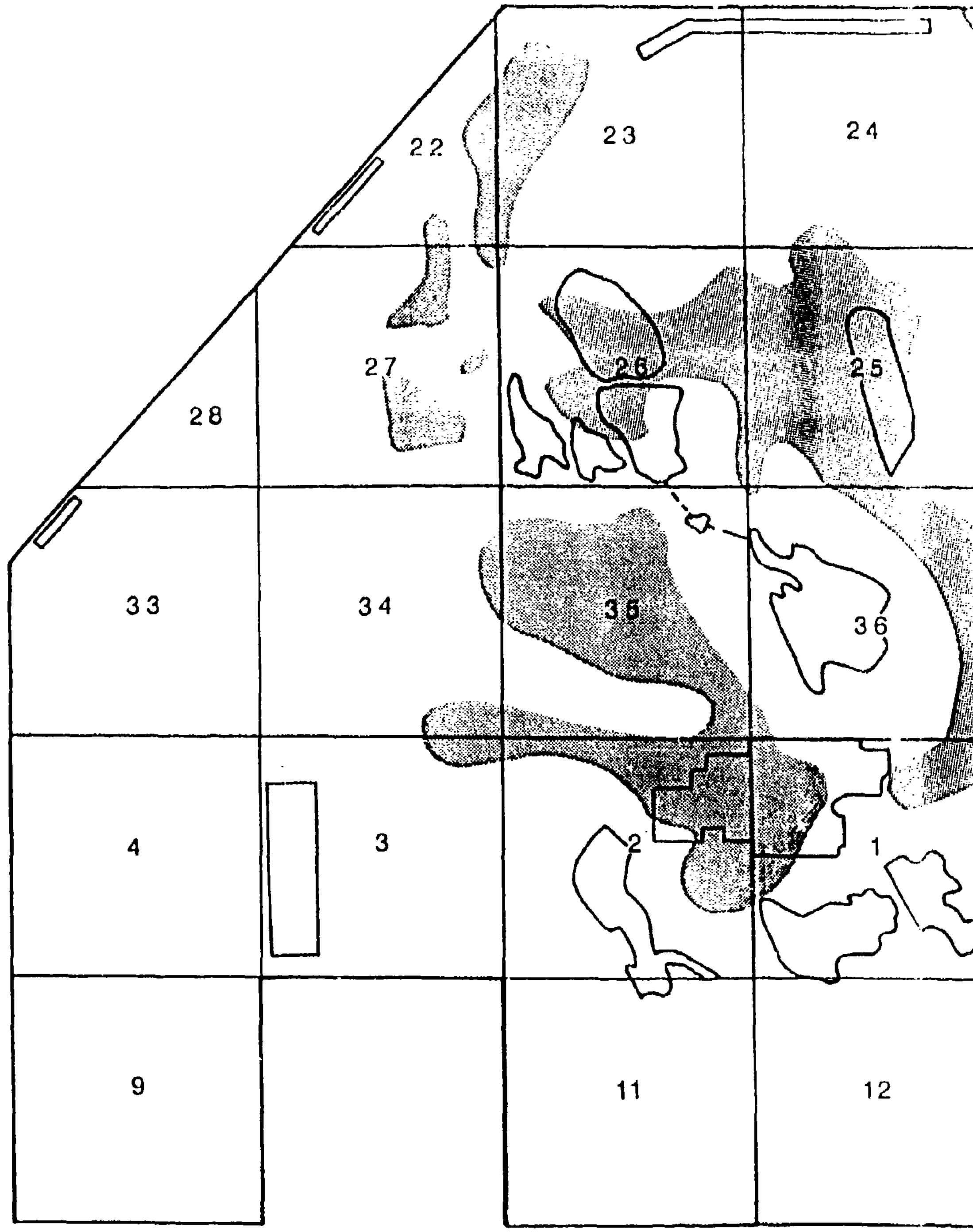
The design of the monitoring well network in the saturated alluvium included consideration of the factors described in the previous section of this Letter Technical Plan and other criteria specific to the alluvial system. The specific criteria included:

- Areas of unsaturated alluvium where alluvial wells do not exist.
- The existence of the screened interval within alluvium.

- The presence of wells within paleochannels.
- Current alluvial ground water flow patterns.

There are large areas within RMA in which the alluvium overlying the Denver Formation is unsaturated (Figure 4). Alluvial ground-water monitoring wells are absent in these areas. Wells selected to monitor the alluvial aquifer were chosen only from wells in which the monitoring interval (well screen plus sand pack/filter) occurs at least partially in alluvium. For areas of unsaturated alluvium an effort was made to assure the Denver monitoring well network included wells from these areas.

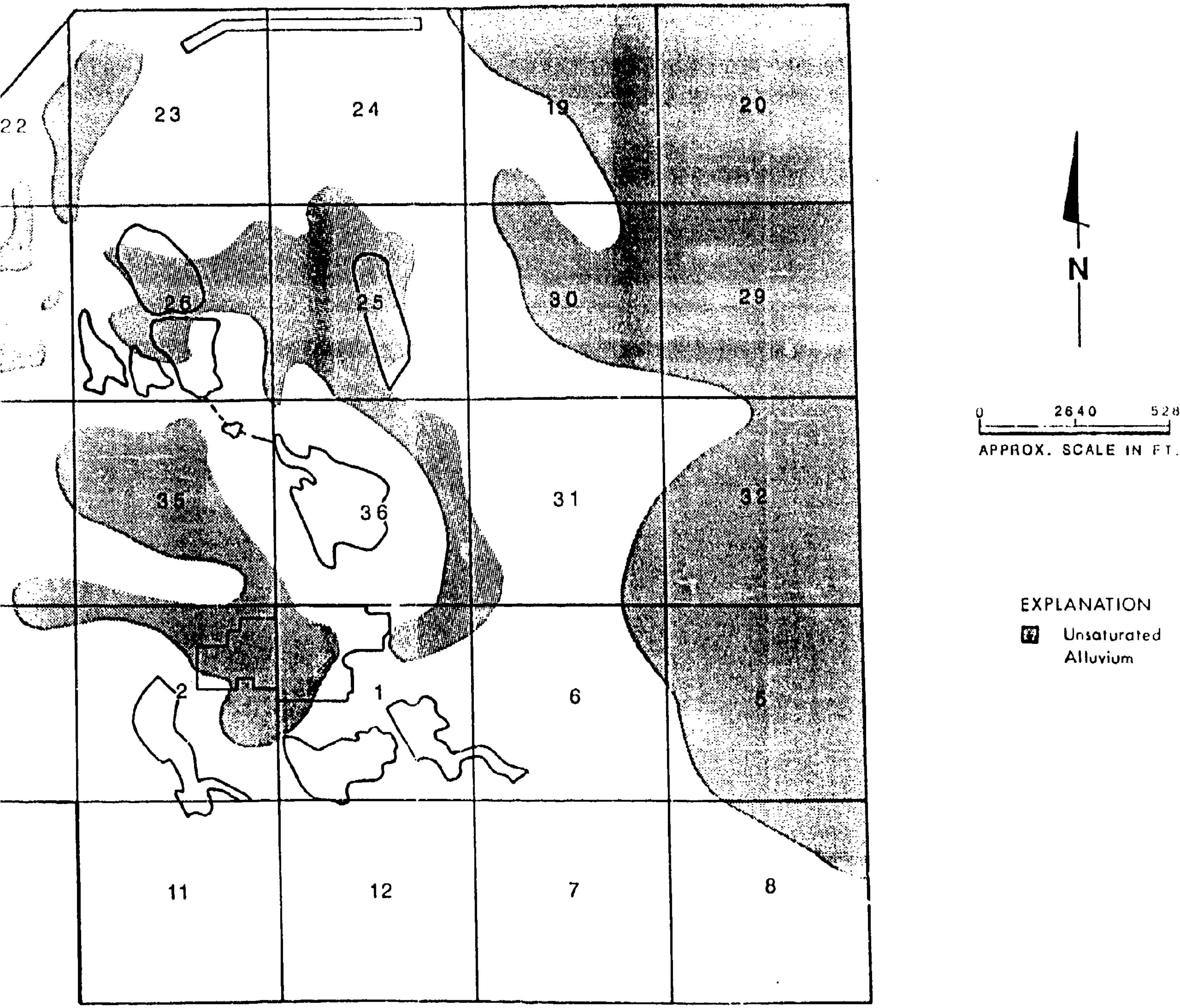
Paleochannels eroded into the surface of the Denver Formation and filled with coarse alluvial sediments (sands and gravels) are generally considered to be a dominant factor affecting ground-water flow in the alluvium. Paleochannels probably represent areas of higher hydraulic conductivity compared to interfluvial areas and probably represent areas of relatively higher velocity ground-water flow and associated contaminant migration. Under thick saturated alluvium conditions, these paleochannels may exhibit less control on directions of ground-water flow and contaminant transport. For conditions where alluvial flow is totally or largely confined to paleochannels, the orientation and morphology of these channels may more strongly influence contaminant migration. In order to identify approximate locations of these paleochannels, a paleochannel map was prepared from available geologic information (Figure 5). These areas received additional consideration in the monitoring well selection so their impact on ground-water flow and contaminant transport could be more fully evaluated. Information for the off-post areas is less detailed and is,



Modified from RIC 83326R01-Selection of Contamination Control S

Figure 4
APPROXIMATE AREAL E
UNSATURATED ALLUVI

SOURCE: HLA, 1987



3326RO1-Selection of Contamination Control Strategy for RMA, Figure 3.

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Figure 4
APPROXIMATE AREAL EXTENT OF UNSATURATED ALLUVIUM

SOURCE: HLA, 1987

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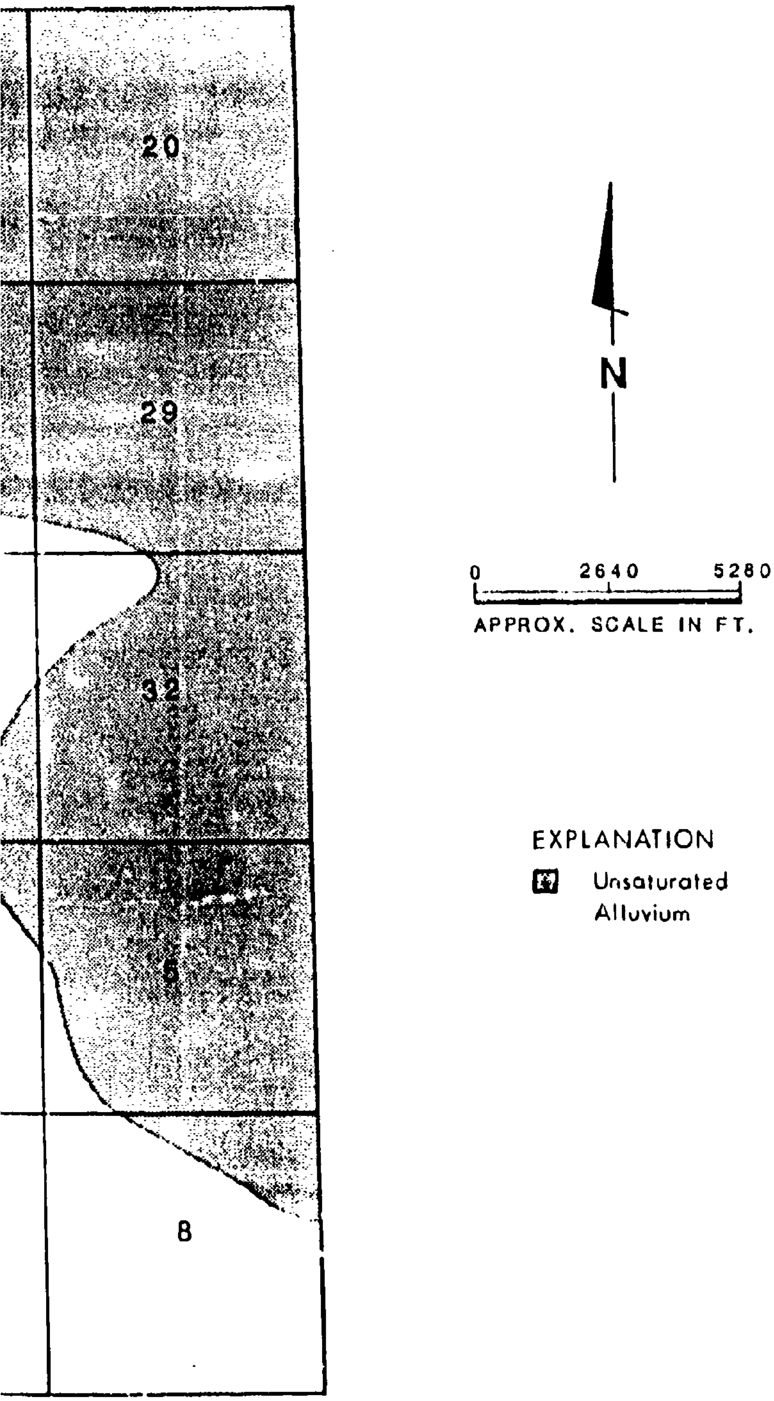

, Figure 3.

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Figure
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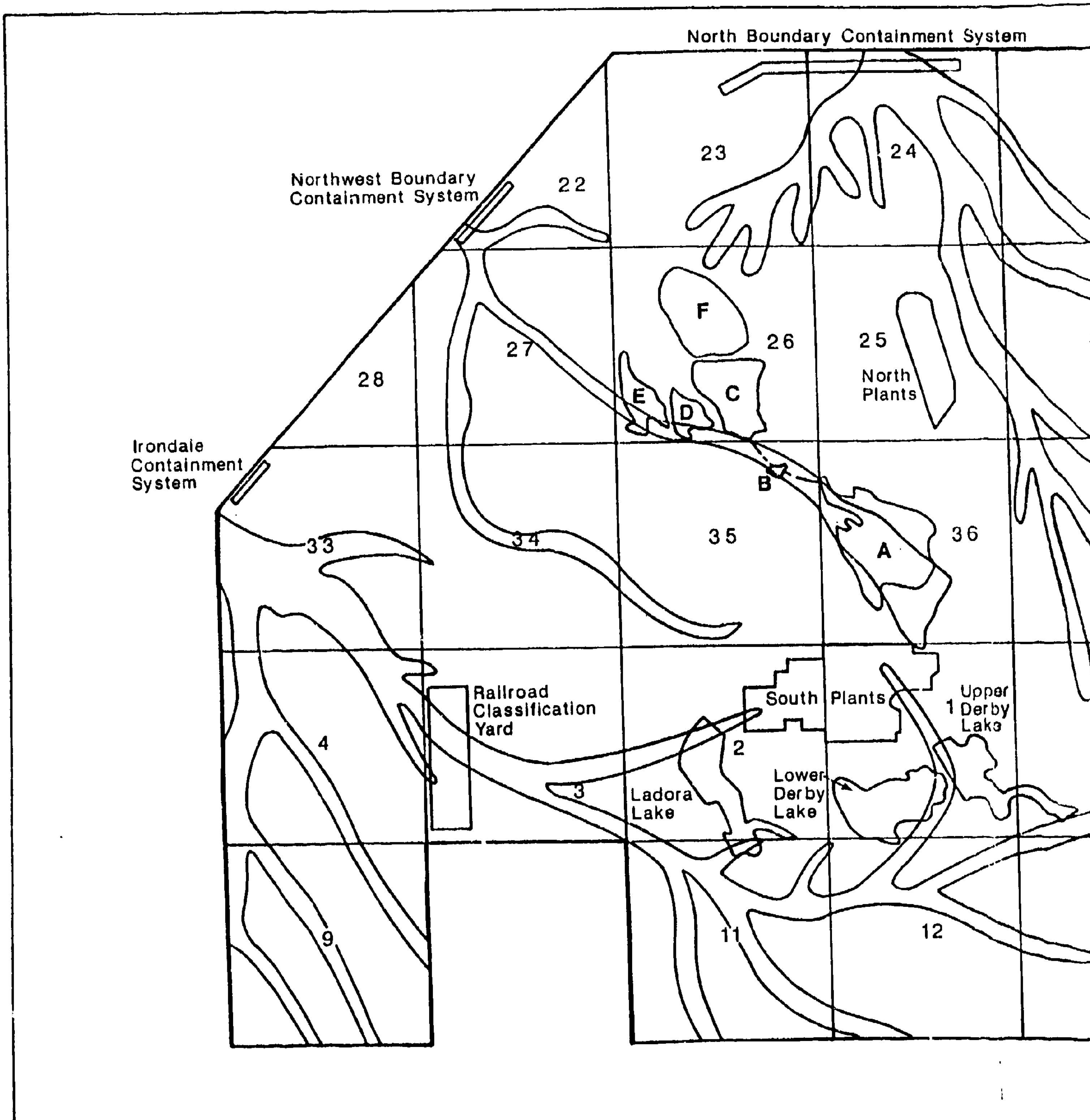
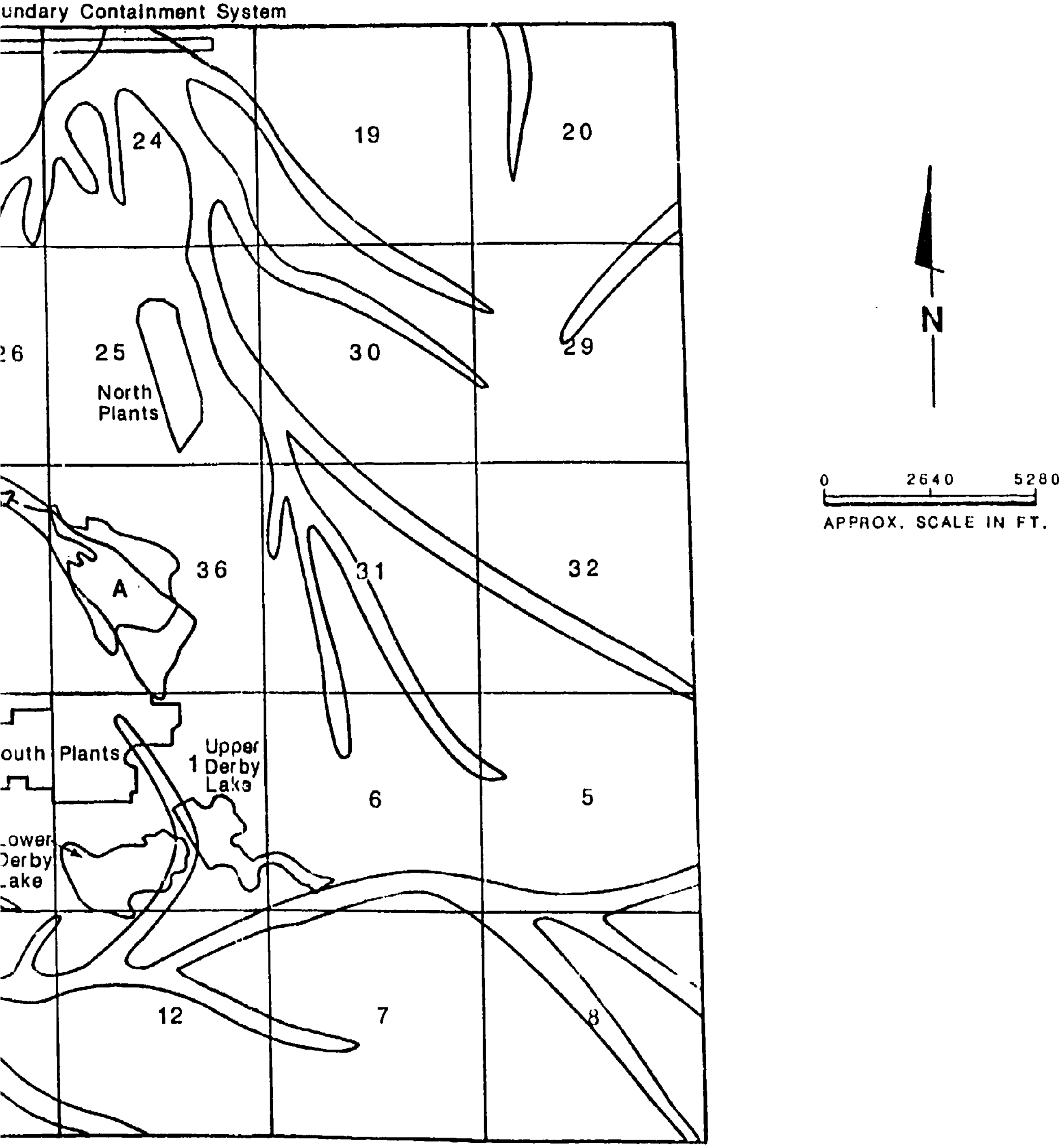


Figure 5
INFERRED BEDROCK PALEO(

SOURCE: HLA, 1987

undary Containment System



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Figur
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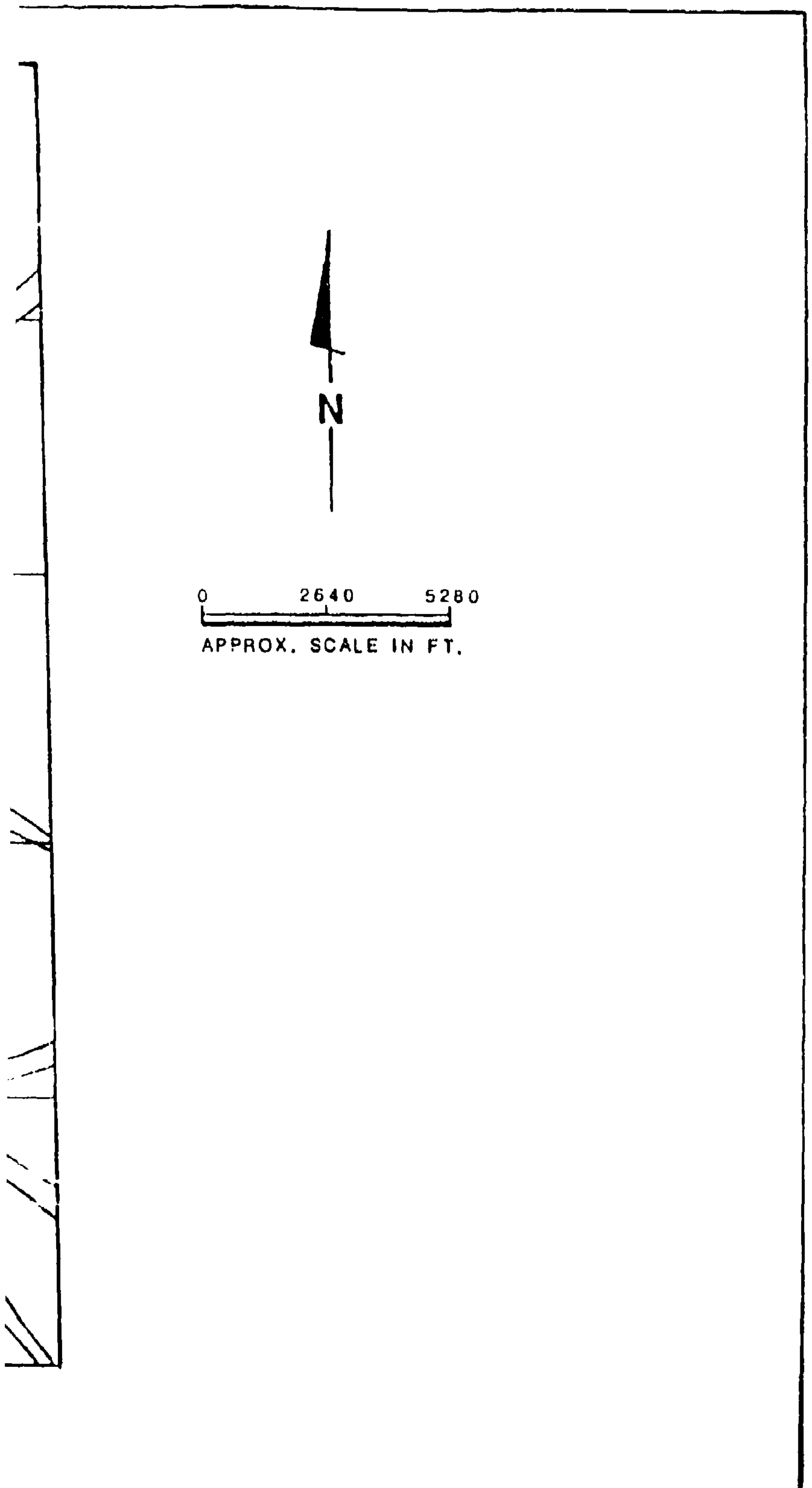

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Figure
5

therefore, not shown. It should be noted that paleochannel boundaries shown in Figure 5 are inferred.

Alluvial ground-water flow patterns were also considered in the design of the monitoring network. Items given particular consideration included flow patterns in the vicinity of the South Plants area and the potential alterations in the flow system in the vicinity of the boundary control systems. Our current understanding of the dominant flow patterns in the alluvium is depicted in Figure 6 with regional flow (large arrows) and localized flow (small arrows) directions shown. Wells were selected for the network to provide both upgradient and downgradient monitoring of major potential contaminant sites and areas of degraded alluvial ground-water quality.

C. Criteria Specific to the Denver Formation Monitoring Network Design

The Denver Formation monitoring network was designed utilizing existing Denver Formation wells according to two classes of criteria. First, those criteria that are common to all well selections (see Section IIIA) and second, criteria that are specific to monitoring within the Denver. These specific criteria are listed below:

- Placement of the screen interval within the Denver Formation.
- Vertical contaminant distributions.
- Aquifer zones within the Denver Formation.
- Vertical hydraulic flow components.
- Areas of unsaturated alluvium.

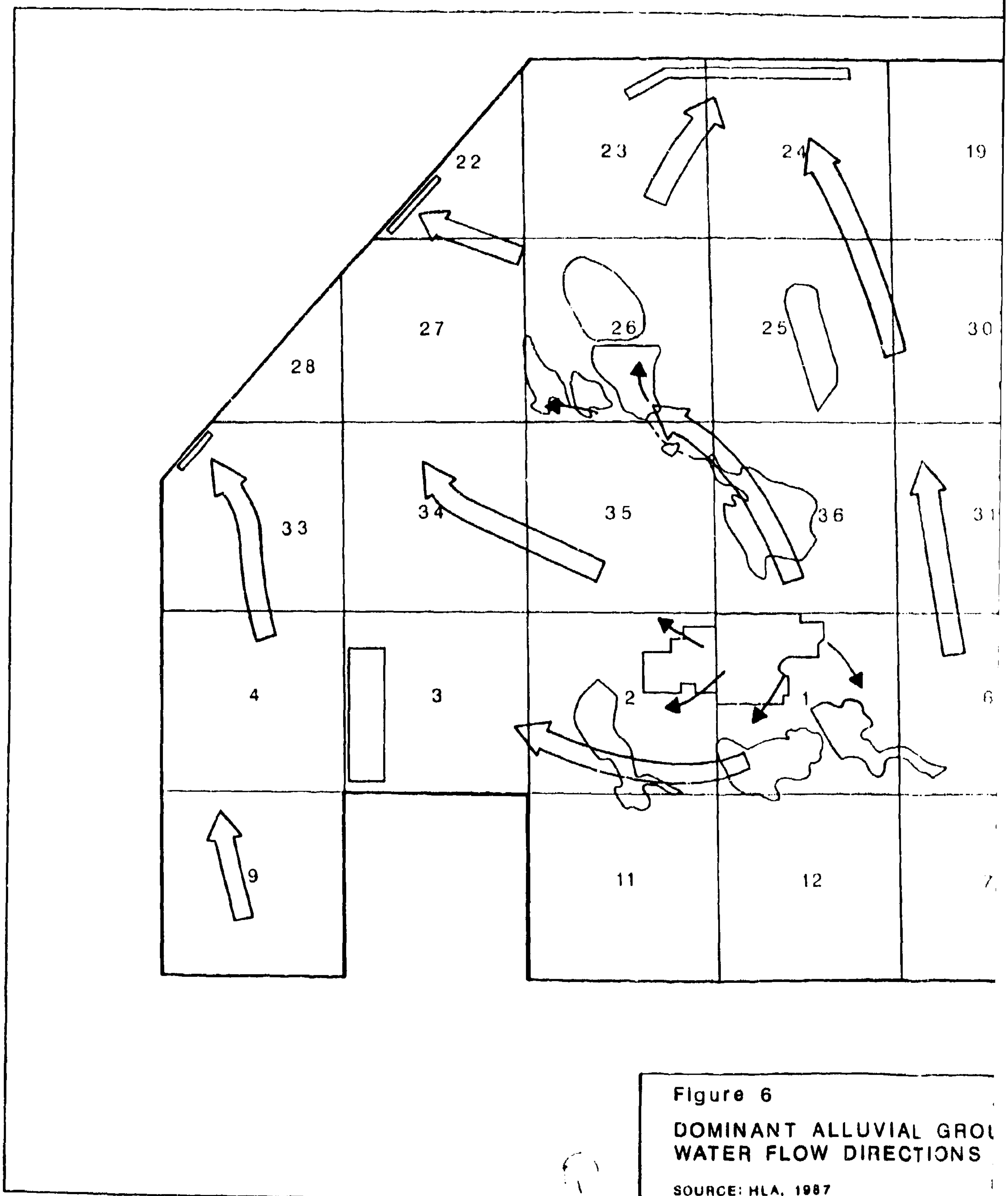
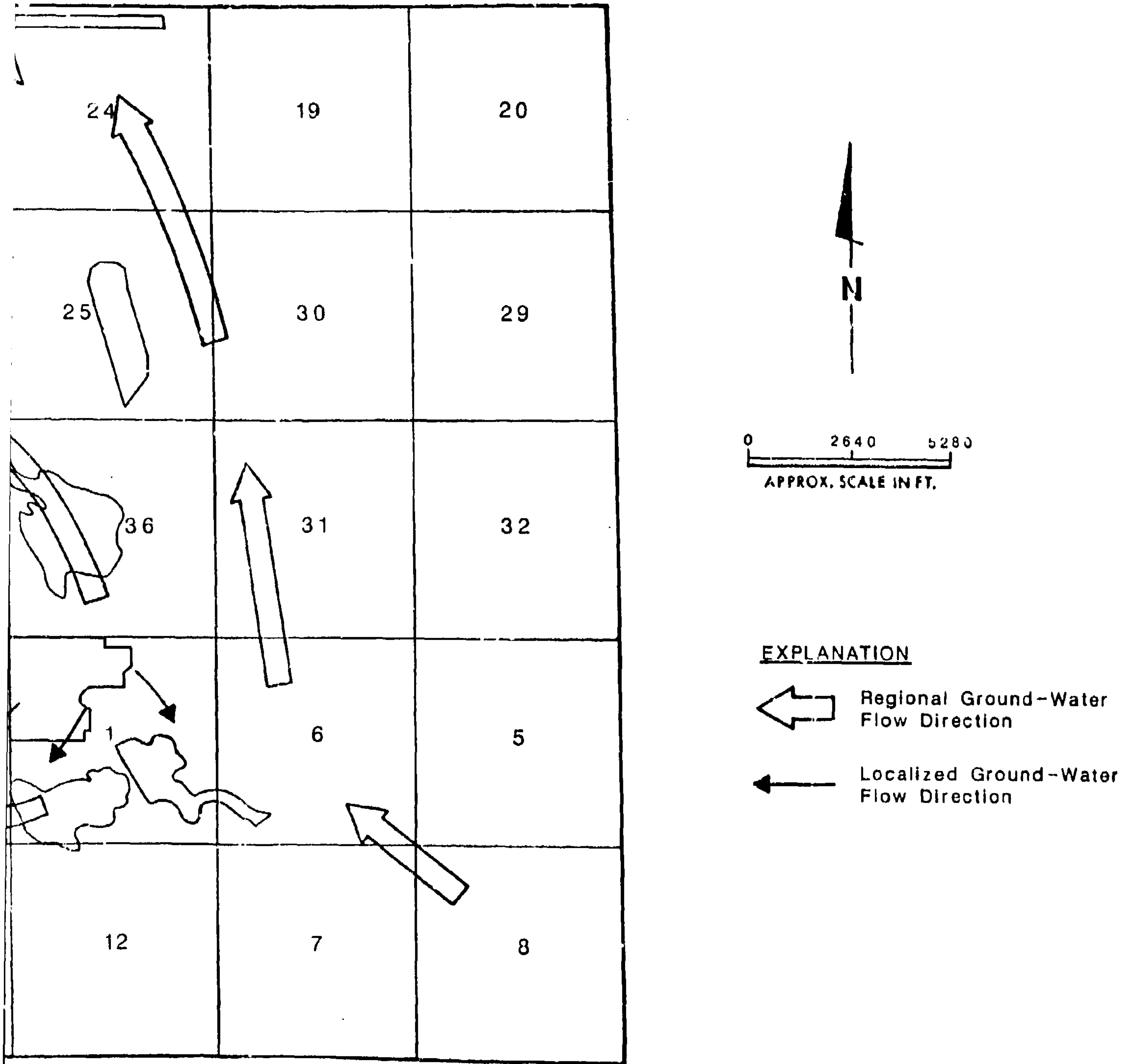


Figure 6

DOMINANT ALLUVIAL GROU
WATER FLOW DIRECTIONS

SOURCE: HLA, 1987



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MINANT ALLUVIAL GROUND
TER FLOW DIRECTIONS

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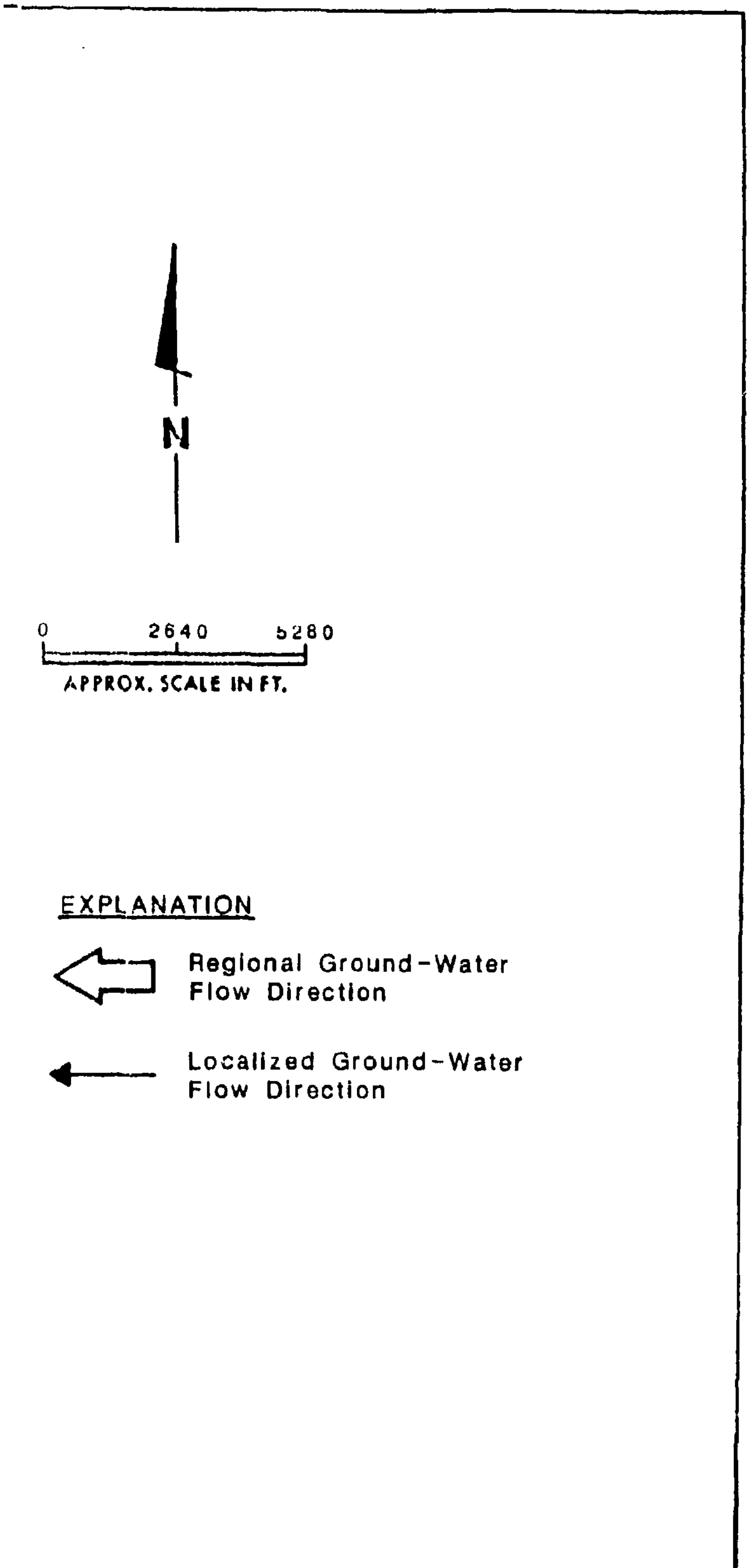

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Figure 6

The vertical contaminant distributions were evaluated for Denver and Denver/Alluvial well clusters. These data were used to evaluate the required maximum depth of monitoring. Generally, if a sampled well contained contaminant concentrations in excess of RMA guidance levels then nearby wells completed in vertically adjacent aquifer zones were considered for monitoring.

Aquifer zones within the Denver Formation were considered in terms of hydraulic communication among wells. This information was used as a general indicator of preferred vertical intervals for monitoring. The use of these data was limited by the presently incomplete data interpretation regarding the geologic continuity of units within the Denver Formation. It is probable that as the hydrostratigraphy of the Denver Formation is better understood, the monitoring network will be refined.

Vertical hydraulic flow components were specifically considered in the Denver Formation monitoring network design as they relate to the need for monitoring various depth ranges within the Denver. In general, if contaminants were present in a well cluster, vertical hydraulic gradients were investigated to determine the relative importance of monitoring wells completed in zones above or below the contaminated zones. Horizontal ground-water flow directions were evaluated to provide information to assess the most appropriate locations for ground-water quality monitoring up- and down-gradient of contaminated areas. Denver monitoring wells were also chosen to provide coverage beneath unsaturated alluvium.

IV. ON-POST LONG-TERM MONITORING NETWORK

The proposed long-term monitoring network for RMA consists of a total of 311 alluvial and Denver Formation wells including 43 off-post wells. Of the 311 wells, 265 wells have either been recently sampled or are proposed for sampling under other RMA tasks or programs as listed below.

- 186 Task 4 wells
- 43 off-post wells
- 25 Task 25 wells
- 11 Task 38 wells

Wells selected for Task 25 have been recently sampled and will be resampled for the complete suite of Task 44 analytes near the end of the first round of Task 44 sampling. Future Task 44 samplings of these wells will be done in coordination with Task 25 sampling. Task 38 wells are scheduled for sampling in April 1987 and, therefore, the sampling of 17 wells which overlap between these two programs will be a coordinated effort. Six of the 17 overlaping wells were also part of Task 4 and are considered as such in the above breakdown.

Except for off-post well locations, all wells were selected utilizing the criteria described previously in SectionIII . The on-post monitoring network has been subdivided into an alluvial network consisting of 128 wells and a Denver Formation network consisting of 140 wells. These networks are discussed separately below. On-post sampling will be conducted semi-annually except for the following 12 wells around Basin F which will be sampled quarterly:

23049	23142	26020	26085
23095	26015	26041	26127
23108	26017	26073	27016

A. Alluvial Well Network

The alluvial monitoring well network was designed to monitor contaminant distributions in saturated RMA alluvium. From all possible alluvial wells, 128 wells were selected. Most of these wells have been sampled within the last year under existing RMA tasks as follows:

- Task 4 wells	84
- Current Task 25 wells	15
- Current Task 38 wells	11
- Historical wells	15
- Recent Shell wells	3
Total Task 44 Wells	128

The alluvial monitoring well network is shown in Figure 7 and summarized by section in Table 2. It should be noted that large portions of RMA have unsaturated alluvium. Therefore, the alluvial well coverage shown in Figure 8 illustrates well coverage in saturated alluvium. Additionally, many of the on-post alluvial wells may be further grouped with respect to locations downgradient of potential contaminant sites. Alluvial wells associated directly with 5 major potential contaminant sites are as follows:

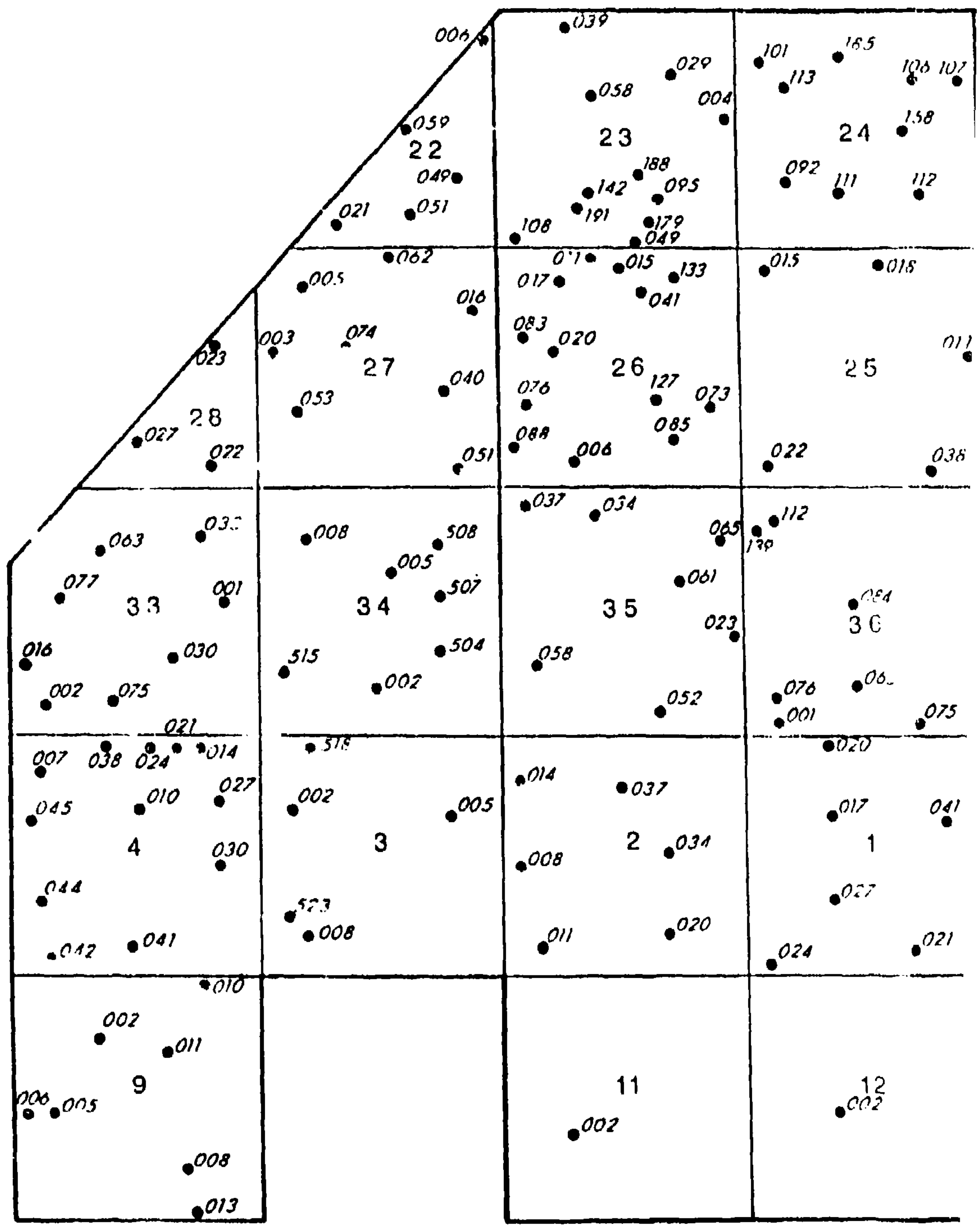

Figure 7

PROPOSED TASK 44 C

MONITORING WELL NE

SOURCE: HLA, 1987

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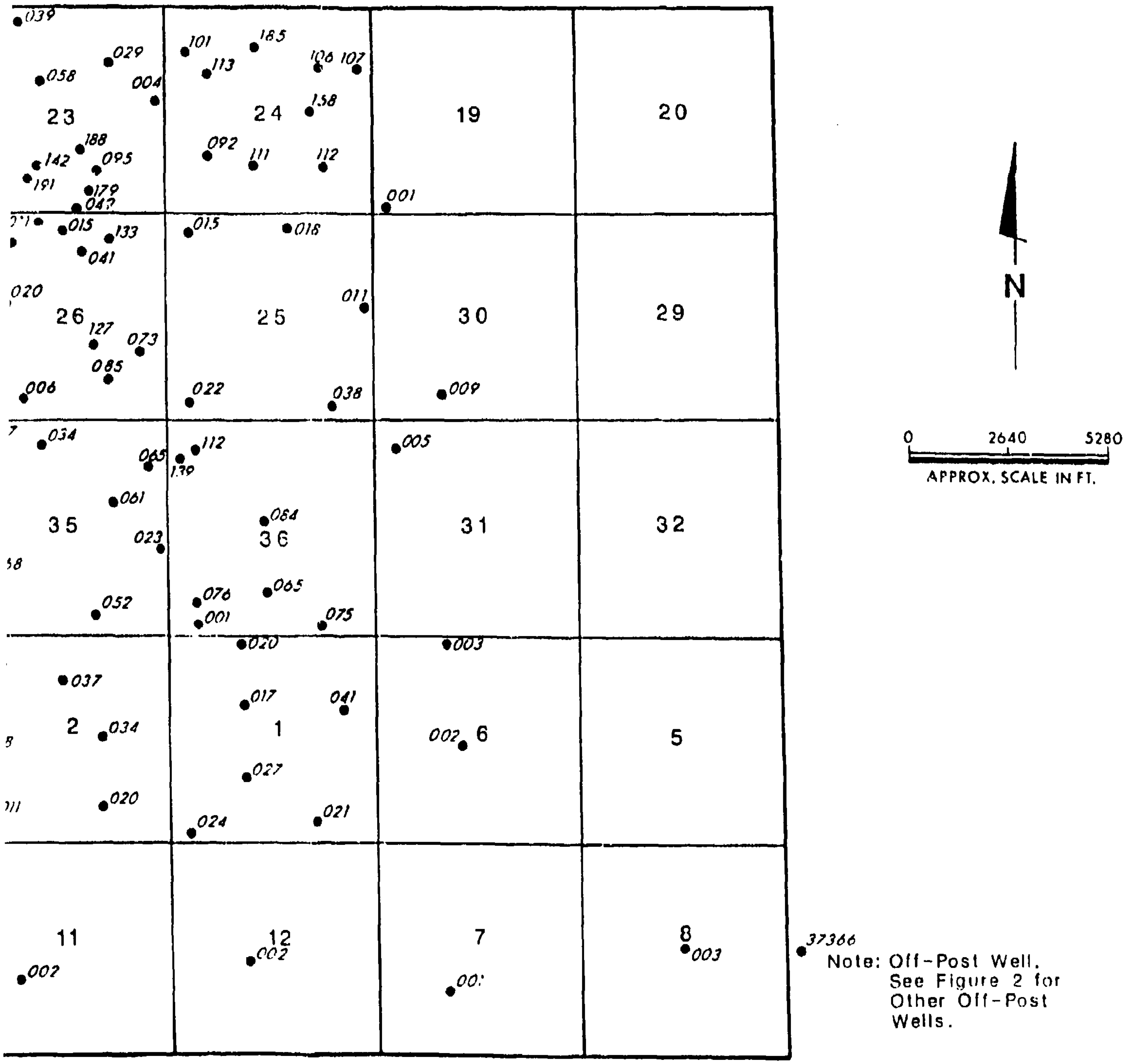

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Figure 7
PROPOSED TASK 44 ON-POST ALLUVIAL MONITORING WELL NETWORK

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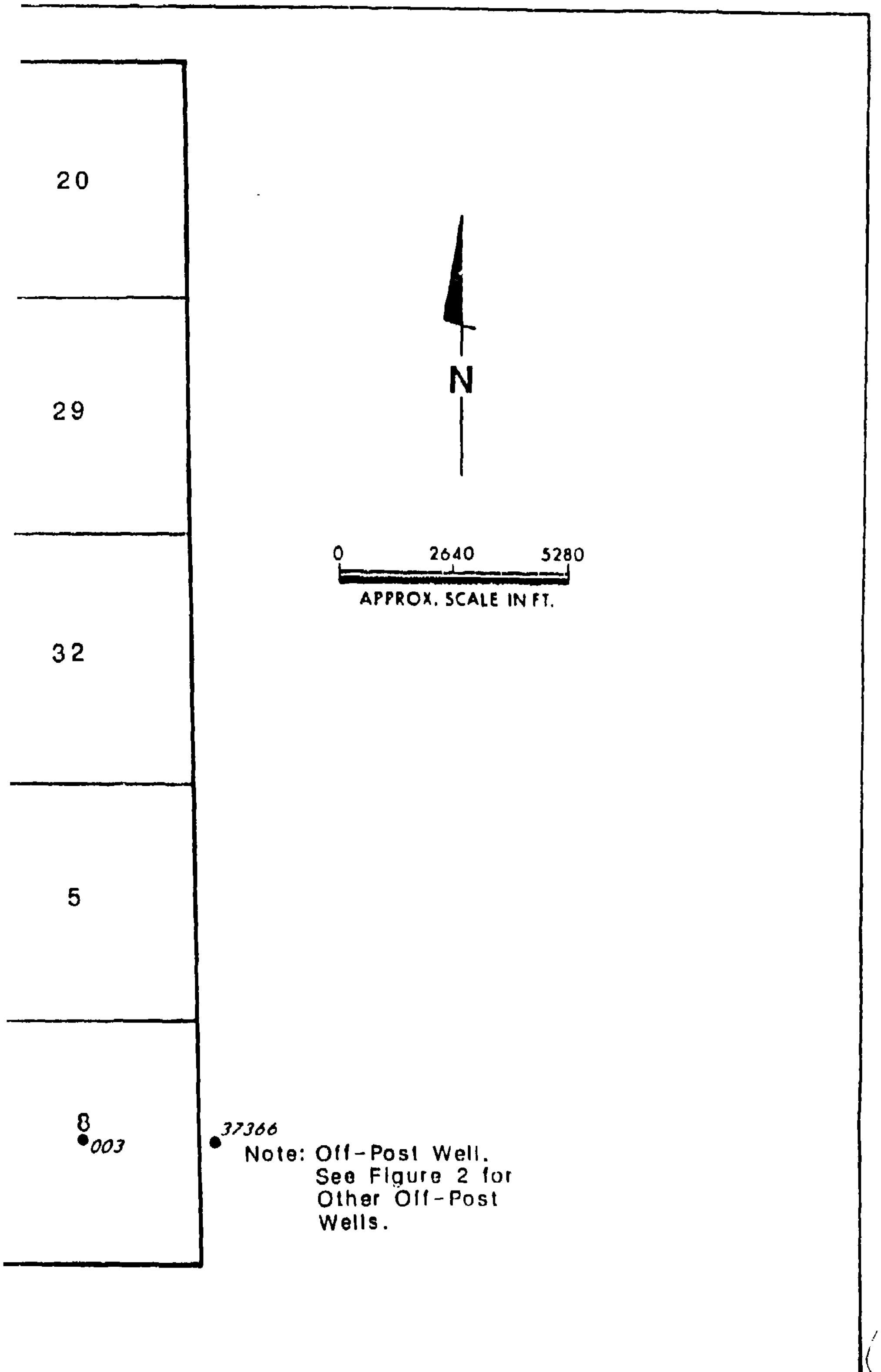

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Figure
7

Table 2: Proposed On-Post Task 44 Monitoring Network
Alluvial Aquifer Wells

Section	Well Numbers
1	017, 020, 021, 024, 027, 041
2	008, 011, 014, 020, 034, 037
3	002, 005, 008, 518, 523
4	007, 010, 014, 021, 024, 027, 030, 038, 041, 042, 044, 045
6	002, 003
7	001
8	003
9	002, 005, 006, 008, 010, 011, 013
11	002
12	002
19	001
22	006, 021, 049, 051, 052
23	004, 029, 039, 049, 058, 095, 108, 142, 179, 188, 191
24	092, 101, 106, 107, 111, 112, 113, 158, 185
25	011, 015, 018, 022, 038
26	006, 011, 015, 017, 020, 041, 073, 076, 083, 085, 088, 127, 133
27	003, 005, 016, 040, 051, 053, 062, 074
28	022, 023, 027
30	009
31	005
33	001, 002, 016, 030, 033, 063, 075, 077
34	002, 005, 008, 504, 507, 508, 515
35	023, 034, 037, 052, 058, 061, 065
36	001, 065, 075, 076, 084, 112, 139

Note: Task 4 Wells -	84
Current Task 25 Wells -	15
Task 38 Wells -	11
Historic Wells -	15
Recent Shell Wells -	3
Total Task 44 Wells -	128

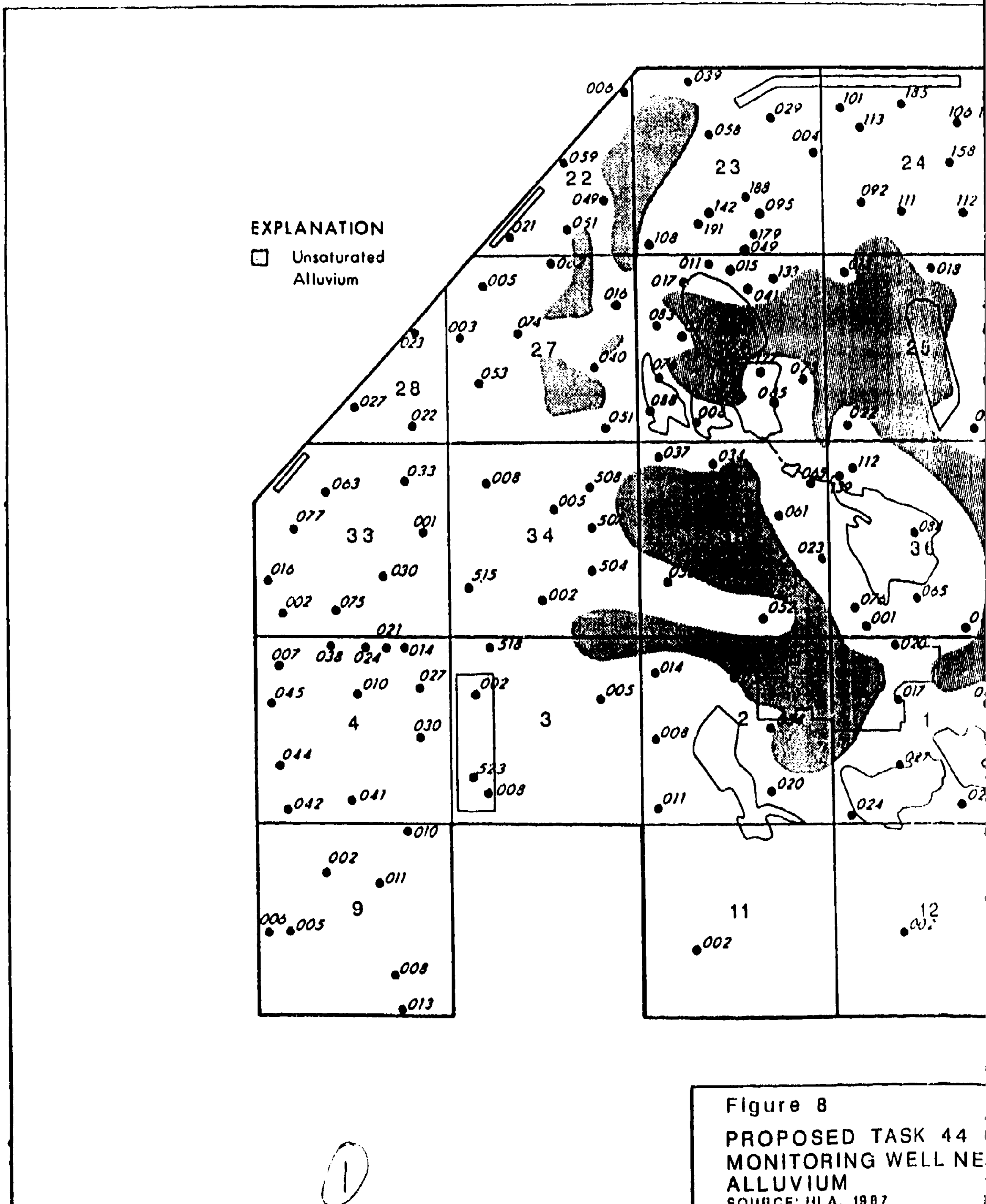

Figure 8
PROPOSED TASK 44
MONITORING WELL NE
ALLUVIUM
SOURCE: HLA, 1987

1

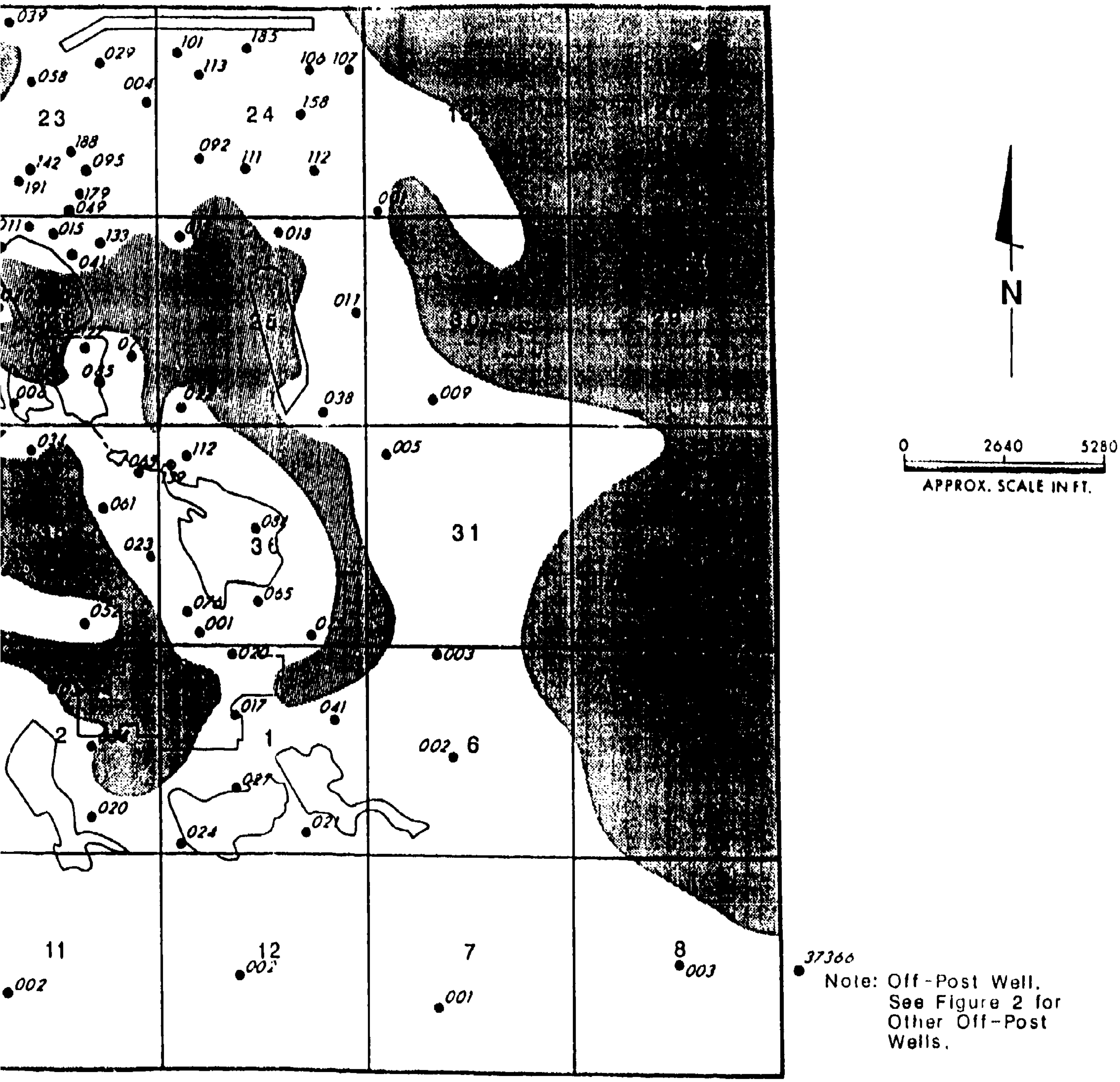

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Figure 8

PROPOSED TASK 44 ON-POST ALLUVIAL MONITORING WELL NETWORK AND UNSATURATED ALLUVIUM

SOURCE: HLA, 1987

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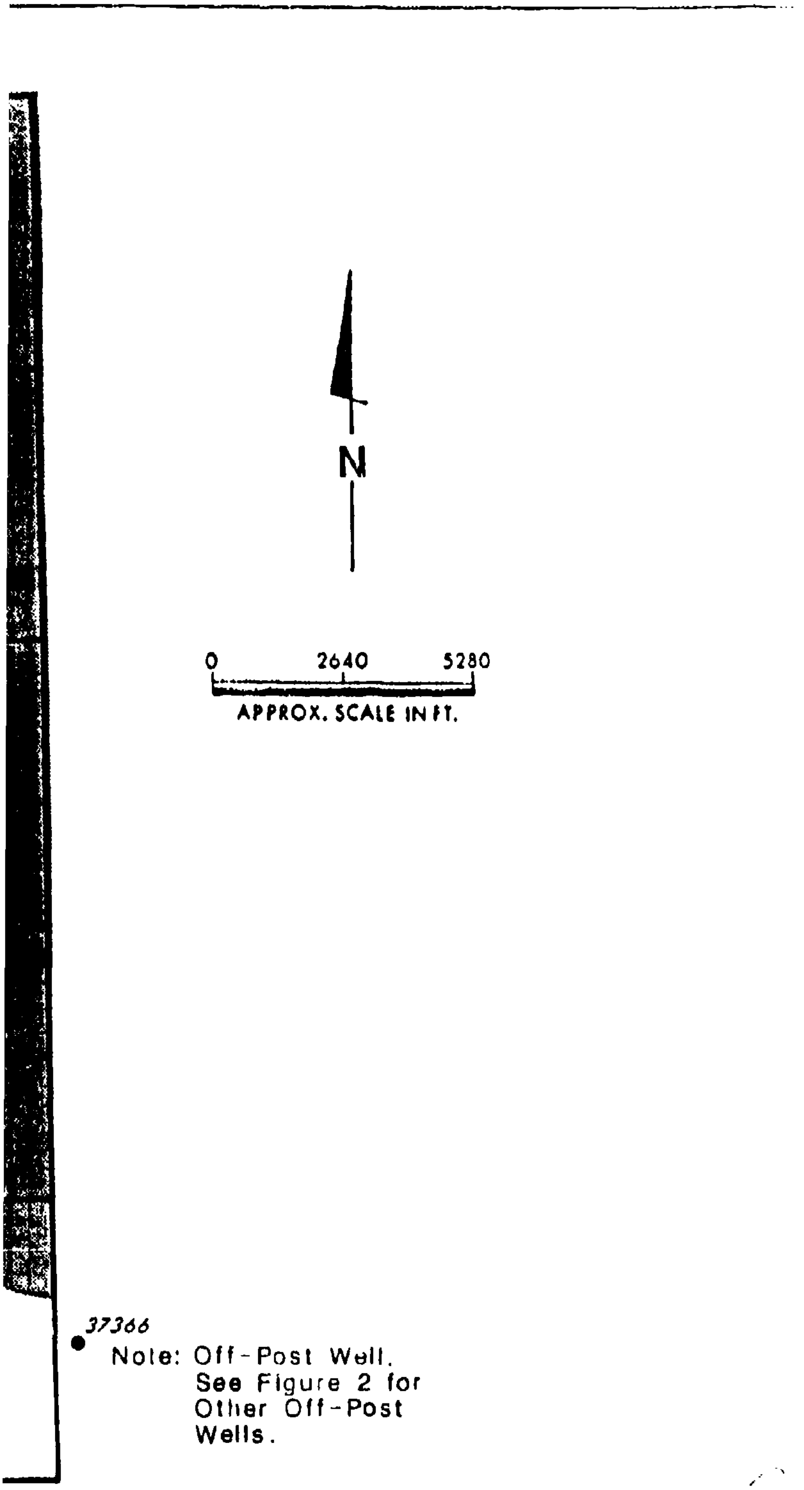

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Figure
8

Potential Contaminant Site	Alluvial Wells
1. South Plants	15
2. Basin A/A neck area	9
3. Basins B-E	8
4. Basin F	25
5. North Plants	5

A total of 27 additional wells (Sections 4, 9, and 33) are included in the program to provide long-term monitoring of the western tier organohalogen and DBCP contamination associated with the Railroad Classification Yard and to monitor potential off-post sources. The alluvial aquifer in these western sections is thicker than at other RMA locations. Wells screened near the base of the alluvial aquifer appear to generally have higher contaminant levels and, therefore, these wells were usually preferred over wells with screens at shallower depths in alluvium.

Paleochannels may play an important role in influencing directions of ground-water flow and in providing contaminant migration pathways facilitating the spread of contamination. Consequently an effort was made when selecting wells to choose wells that were situated within paleochannels or as close to paleochannels as possible. Approximately 42 wells were selected to investigate the effects of paleochannels at RMA (Figure 9). The paleochannels shown in Figure 9 are a composite set taken from the Army/ESE and Shell bedrock surface maps. There appears to be a good correlation between paleochannel orientation and alluvial aquifer flow

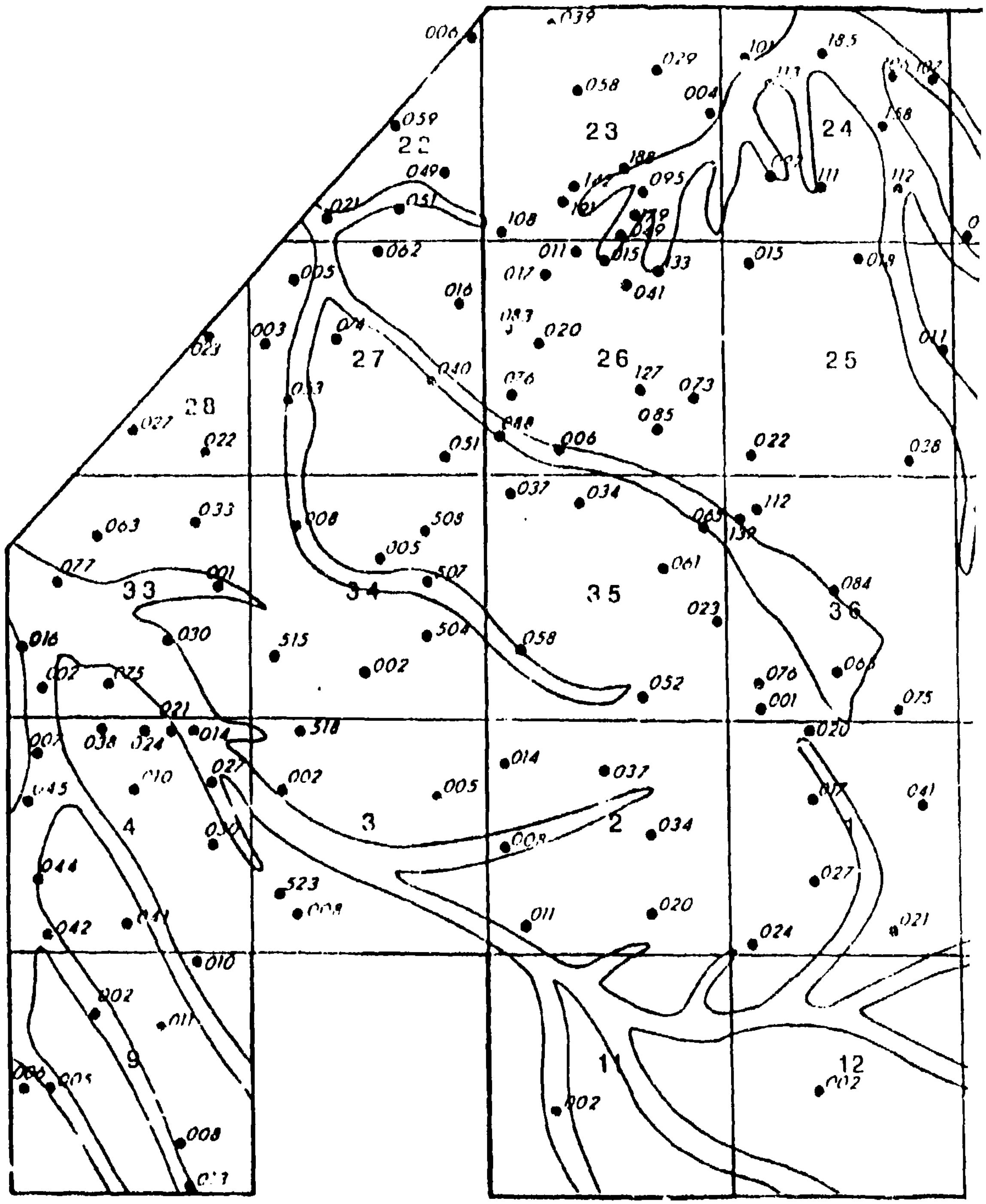

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Figure 9

PROPOSED TASK 44 ON-
WELL NETWORK AND INF
BEDROCK PALEOCHANNE
SOURCE: HLA, 1987

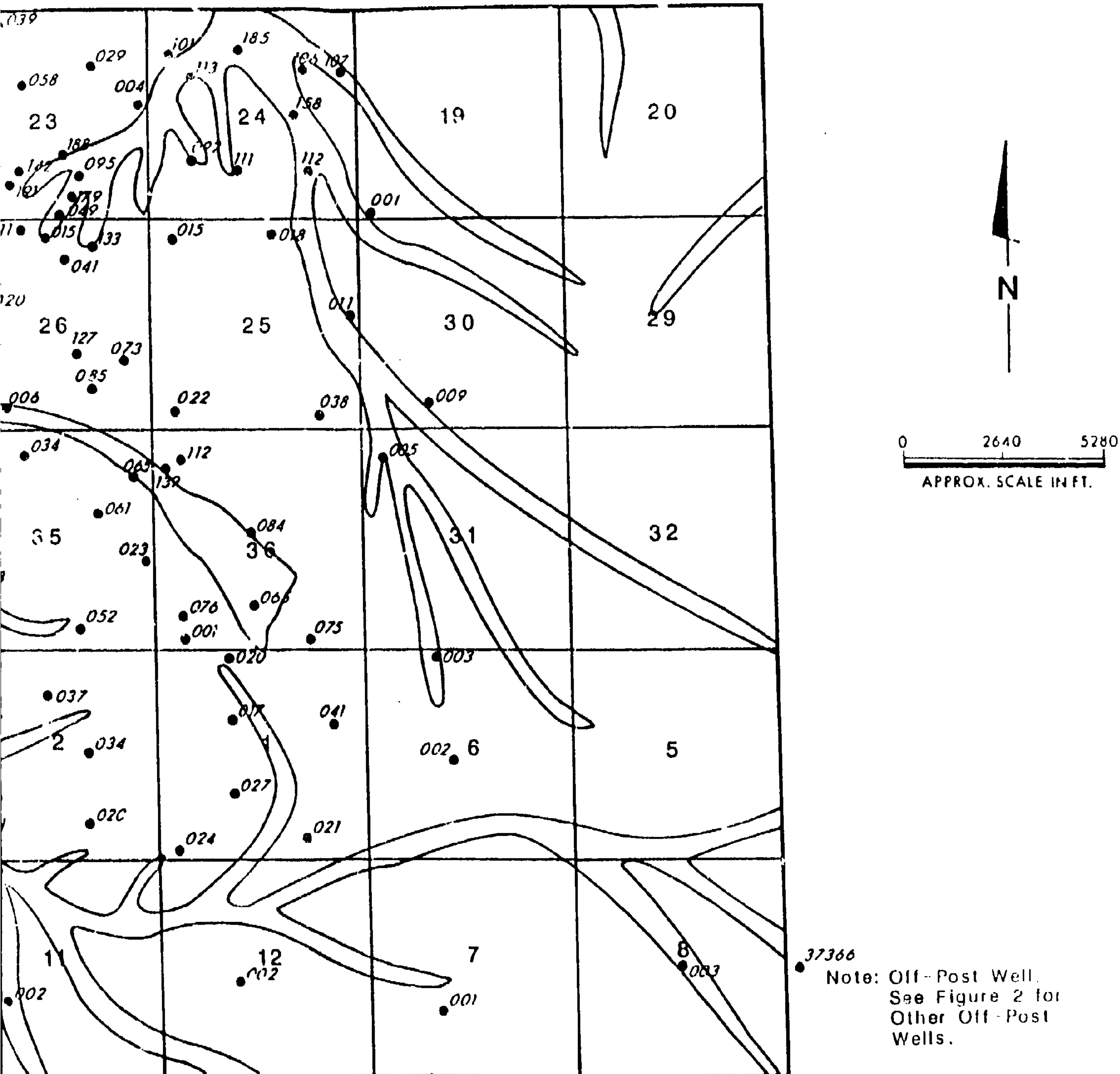

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Figure 9
PROPOSED TASK 44 ON-POST ALLUVIAL MONITORING WELL NETWORK AND INFERRED BEDROCK PALEOCHANNELS
SOURCE: HLA, 1987

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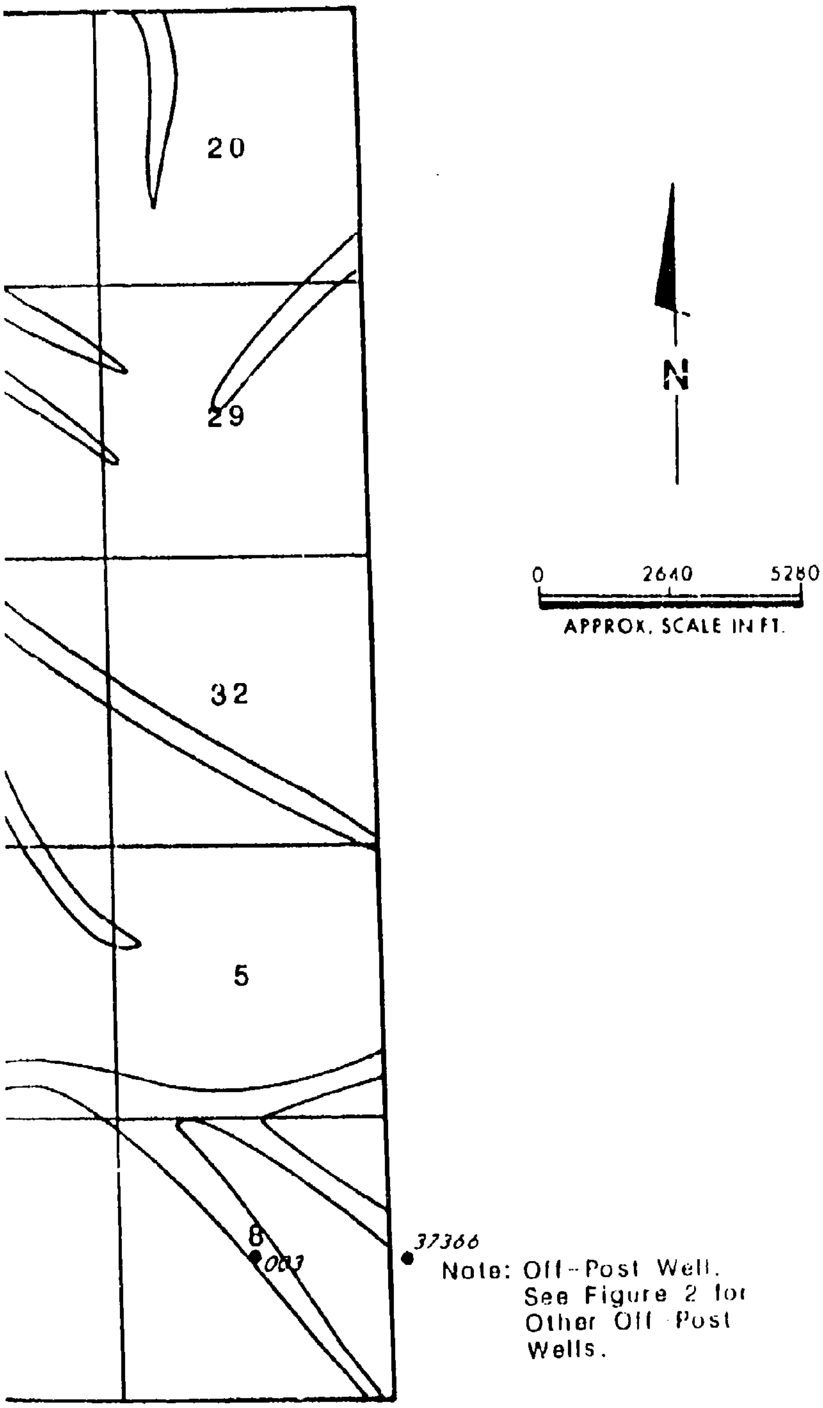

LLUVIAL MONITORING

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Figure
9

directions. Areas with thick zones of saturated alluvium are less likely to show paleochannel flow control.

A set of 5 wells (06002, 07001, 08003, 11002, and 12002) were chosen to provide regional background monitoring of the alluvial aquifer. These wells also provide a general indication of alluvial water quality flowing onto RMA along the southern tier.

A second set of 5 wells (06003, 19001, 25011, 30009, and 31005) were chosen to monitor the eastern side of RMA and provide contaminant boundary definition.

B. Denver Formation Well Network

The Denver Formation monitoring well network includes 139 on-post wells chosen from over 500 on-post wells completed in the Denver Formation. The monitoring network is shown in Figure 10 and individual wells are listed by section, in Table 3. The monitoring network utilizes the best existing Denver Formation wells for both upgradient and downgradient monitoring of potential contaminant sites. Most of the selected Denver Formation wells have been sampled under other RMA tasks within the last year as outlined below.

- Current Task 25 wells	10
- Task 4 wells	102
- Historic wells	28
Total Task 44 Wells	140

Additionally, many of the on-post Denver wells may be further grouped with respect to their location to potential contaminant sites. Wells associated directly with 5 major potential contaminant sites are as follows:

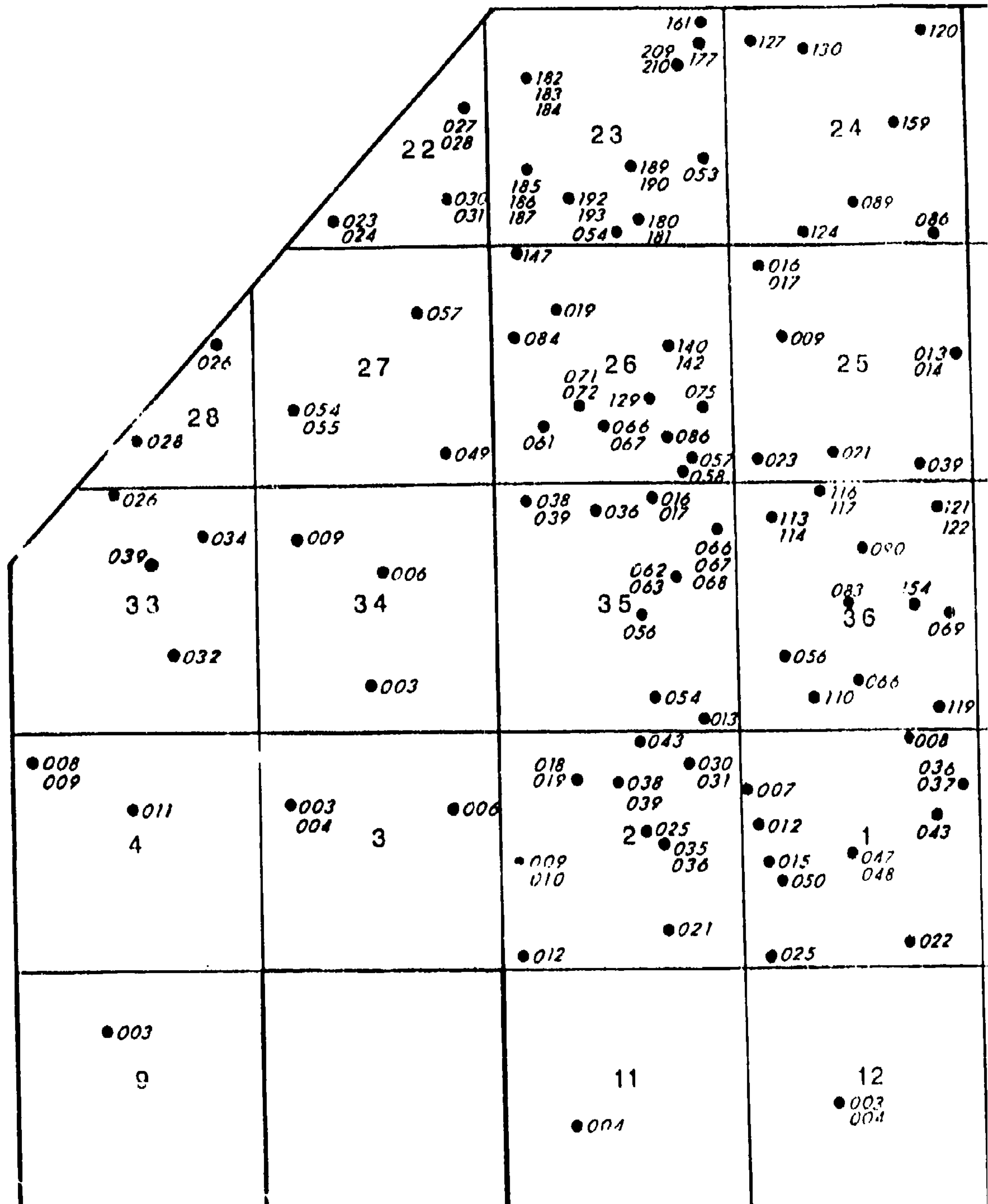


Figure 10
PROPOSED TASK 44 ON
MONITORING WELL NET

SOURCE: HLA, 1987

1

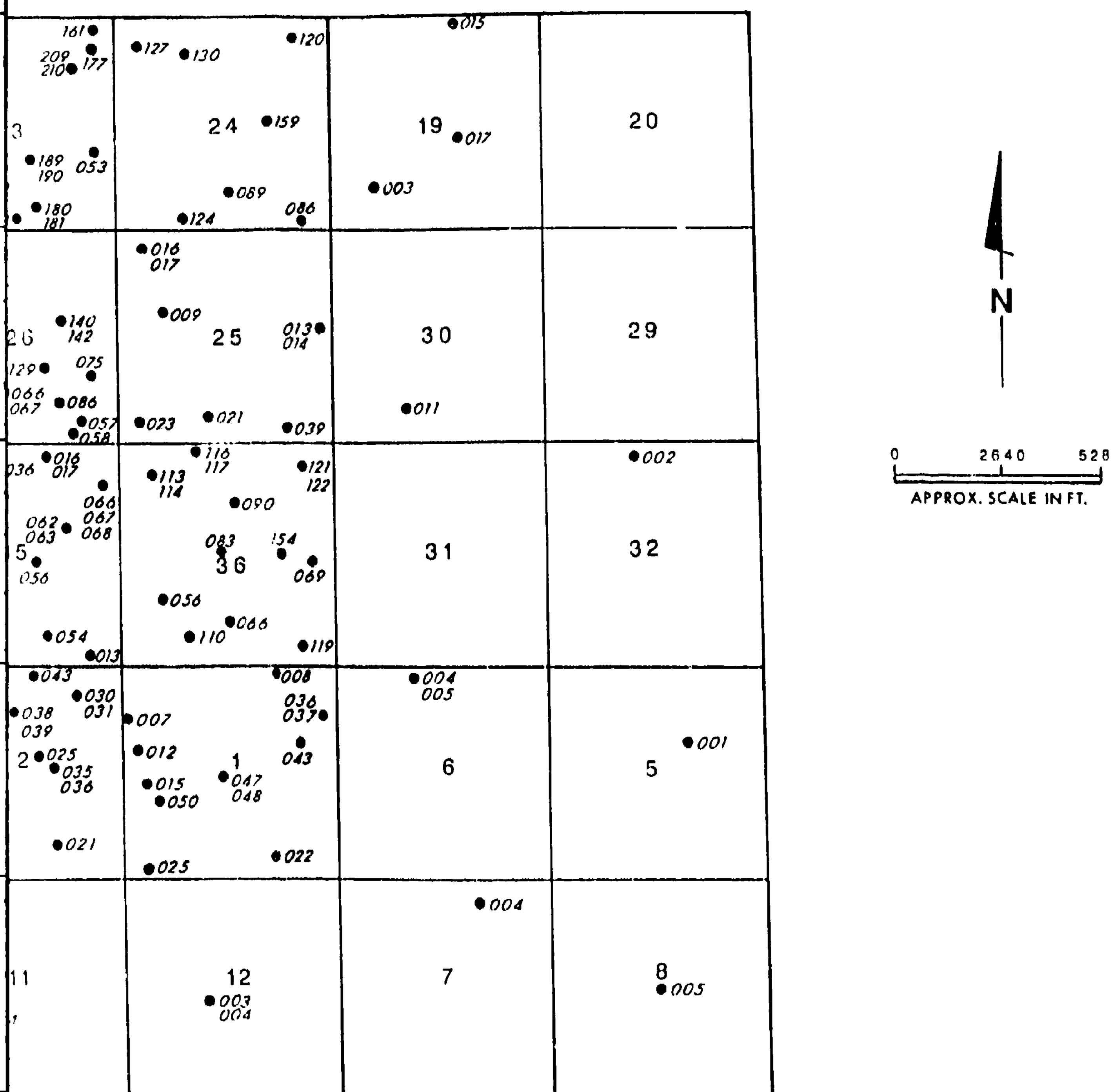
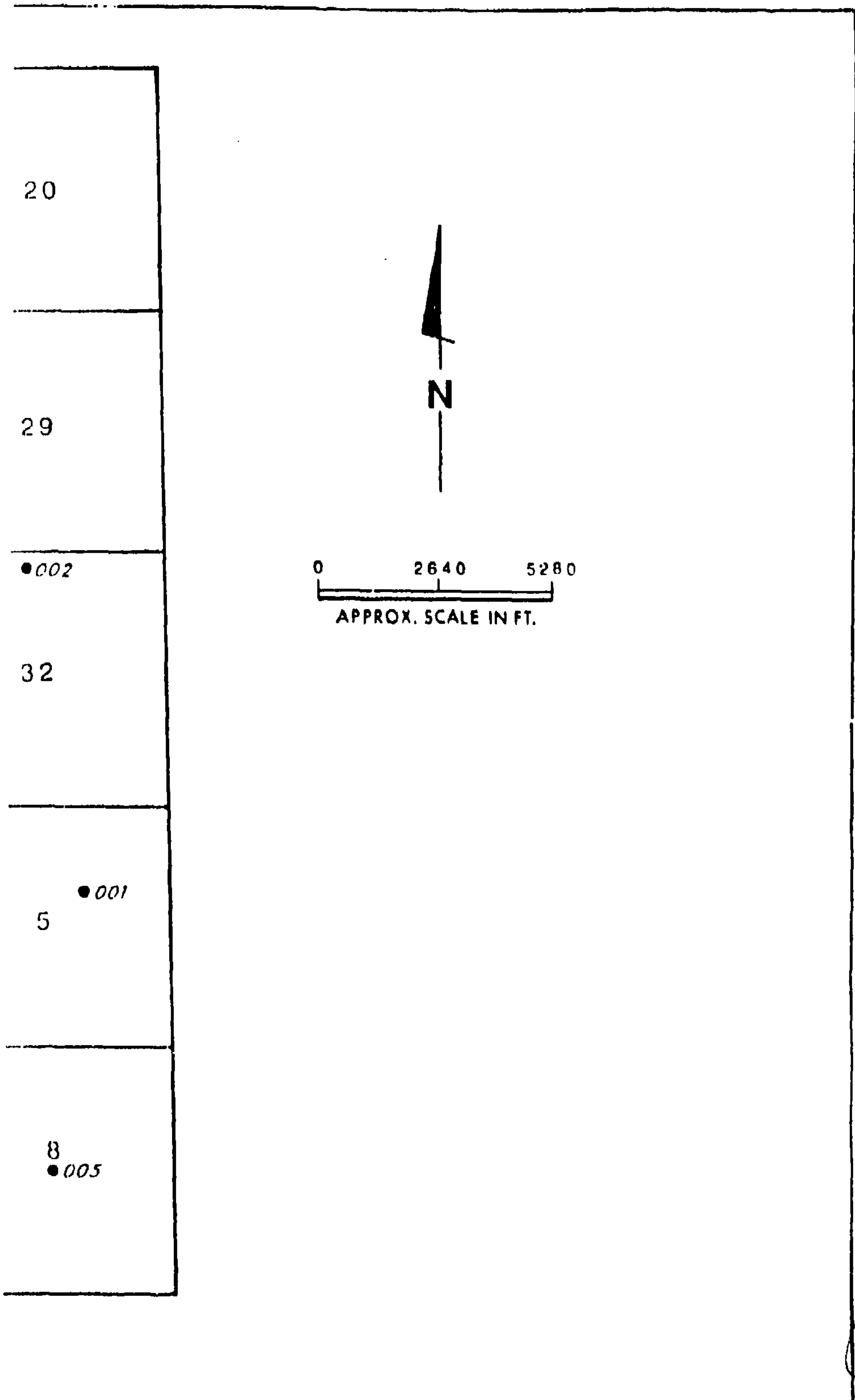


Figure 10
PROPOSED TASK 44 ON-POST DENVER FORMATION MONITORING WELL NETWORK

SOURCE: HLA, 1987

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland



RMATION	**Prepared for:** **U.S. Army Program Manager's Office** **For Rocky Mountain Arsenal** **Aberdeen Proving Ground, Maryland**	Figure 10

Table 3: Proposed On-Post Task 44 Monitoring Network
Denver Formation Wells

Section	Well Numbers
1	007, 008, 012, 015, 022, 025, 036, 037, 043, 047, 048, 050
2	009, 010, 012, 018, 019, 021, 025, 030, 031, 035, 036, 038, 039, 043
3	003, 004, 006
4	008, 009, 011
5	001
6	004, 005
7	004
8	005
9	003
11	004
12	003, 004
19	003, 015, 017
22	023, 024, 027, 028, 030, 031
23	053, 054, 161, 177, 180, 181, 182, 183, 184, 185, 186, 187, 189, 190 192, 193, 209, 210
24	086, 089, 120, 124, 127, 130, 159
25	009, 013, 014, 016, 017, 021, 023, 039
26	019, 057, 058, 061, 066, 067, 071, 072, 075, 084, 086, 129, 140 142, 147
27	049, 054, 055, 057
28	026, 028
30	011
32	002
33	026, 032, 034, 039
34	003, 006, 009
35	013, 016, 017, 036, 038, 039, 054, 056, 062, 063, 066, 067, 068
36	056, 066, 069, 083, 090, 110, 113, 114, 116, 117, 119, 121, 122, 154

Note: Current Task 25 Wells - 10
Task 4 Wells - 102
Historic Wells - 28
Total Task 44 Wells - 140

Potential Contaminant Sites	Denver Wells
1. South Plants	25
2. Basin A/A neck area	17
3. Basins B-E	13
4. Basin F	16
5. North Plants	10

Eight wells from Sections 4, 9, and 33 are also included within the network to provide long-term monitoring of the western tier organohalogen and DBCP contamination associated with the Railroad Classification Yard and to monitor potential off-post sources. Current information suggests these contaminants are presently restricted to the alluvial aquifer. A more extensive monitoring of the Denver aquifer is warranted to provide assurance that contamination is not spreading to the Denver Formation.

A set of 5 wells (07004, 08005, 11004, 12003, and 12004) were chosen to provide regional background monitoring of the Denver Formation aquifer. These wells also provide a general indication of Denver Formation water quality flowing onto RMA along the southern tier.

A set of 8 wells (05001, 06004, 06005, 19003, 19015, 19017, 30011, and 32002) monitor the eastern sections of RMA. These wells provide general information on Denver Formation water quality and/or contaminant boundary definition.

Following examination of Task 4 data, it was determined that the Denver Formation ground-water flow and contaminant transport systems were not as well defined as the alluvial system. Therefore, the monitoring

network selected for the Denver Formation includes a larger percentage of Denver wells than were included in the Task 4 network. As a result, a more comprehensive evaluation of all available data was necessary. This resulted in utilization of more historical wells relative to the alluvial network.

Based on preliminary evaluations of existing hydrologic data and geologic cross sections, three major hydrogeologic zones of the Denver Formation are proposed. These zones are found beneath the Basin A/South Plants area and may be described as follows:

1. A lenticular channel sand generally ranging from 10 to 50 feet thick and situated 10 to 50 feet above a lignitic horizon.
2. Thin (2 to 10 ft) sands in close proximity to a semi-continuous 5 to 7 feet thick lignite bed.
3. A massive tabular sand averaging 50 feet thick and situated 50 feet below the lignitic associated sands.

However, it appears these zones are not continuous across RMA given our knowledge of the depositional and structural environment of the Denver Formation. Outside of this area, most wells in the Denver monitoring network have screen intervals in similar zones. Although these zones appear similar to the Basin A/South Plants zones, they are not believed to be geologically continuous. Nevertheless, these zones may be hydrologically continuous. Task 44 will investigate the geologic and hydrologic continuity of these zones.

Water elevations measured from well clusters penetrating these zones commonly display differences of 5 to over 30 feet and indicate potential downward flow. Therefore, to allow examination of vertical differences in

hydraulic head, a preference was given to include wells in a cluster configuration within the Task 44 network. Table 4 lists all wells in the task network that are present in cluster configurations.

C. Summary

The recommended ground-water monitoring network for Task 44 includes 128 on-post alluvial wells, 140 on-post Denver Formation wells, and 43 off-post monitoring wells. The Task 44 network is the framework for monitoring regional water quantity and water quality. Therefore, other ground-water related tasks are superimposed on the Task 44 network. Currently the Task 44 network includes 25 on-post wells from Task 25 and 11 wells from the Task 38 network (Table 5). A few wells may be added or subtracted depending on results from the detailed studies in Tasks 25, 26, 36, 38, and 39.

V. CHEMICAL ANALYSIS

The Task 44 scope of work includes semi-annual sampling of the monitoring network presented in this Letter Technical Plan. All samples will be analyzed for a complete suite of target compounds similar to the list of target analytes for the Initial Screening Program of Task 4. The Task 44 analytical schedule also includes analysis for the complete list of major cations and anions.

Table 6 contains a list of all target analytes. Depending on the results of the first semi-annual sampling, the analytical suite may be reduced for the second semi-annual sampling. These reductions may be performed on a regional basis. However, annually the regional long-term

Table 4: Clustered Wells Incorporated in the Proposed Task 44 On-Post Monitoring Network

Section	Clusters
1	(021*, 022), (024*, 025), (041*, 043)
2	(008*, 009, 010), (011*, 012), (020*, 021), (034*, 035, 036), (037*, 038, 039)
3	(002*, 003, 004), (005*, 006)
4	(007*, 008, 009), (010*, 011)
6	(003*, 004, 005)
8	(003*, 005)
9	(002*, 003)
11	(002*, 004)
12	(002*, 003, 004)
22	(021*, 023, 024)
23	(179*, 180, 181), (188*, 189, 190), (191*, 192, 193)
24	(158*, 159)
25	(011*, 013, 014), (015*, 016, 017), (022*, 023), (038*, 039)
26	(073*, 075), (083*, 084), (085*, 086), (127*, 129)
27	(053*, 054, 055)
28	(023*, 026), (027*, 028)
30	(009*, 011)
33	(030*, 032), (033*, 034)
34	(002*, 003), (005*, 006)
35	(034*, 036), (037*, 038, 039), (052*, 054), (061*, 062, 063), (065*, 066, 067, 068)
36	(065*, 066), (112*, 113, 114)

*Alluvial well

Table 5: Wells Incorporated in the Proposed Task 44 Network From Other Current RMA Monitoring Programs

TASK 25 WELLS (25)

Denver	Alluvial
22023, 22031, 23181, 23184, 23189, 23209, 23210, 24086, 24120, 24124	22006, 22049, 22051, 23004, 23029, 23039, 23058, 24092, 24101, 24106, 24111, 24113, 24185, 27003, 27074

TASK 38 WELLS (11)

Denver	Alluvial
None	04038, 04041, 04042, 04044, 04045, 09008, 09010, 09011, 09013, 33075, 33077

Table 6: Target Analytes - Task 44

Organochlorine Pesticides

- Aldrin
- Endrin
- Dieldrin
- Isodrin
- Hexachlorocyclopentadiene
- p,p'-DDE
- p,p'-DDT

Volatile Organohalogens

- Chlorobenzene
- Choroform
- Carbon Tetrachloride
- trans-1,2-Dichloroethylene
- Trichloroethylene
- 1,1 Dichloroethylene
- 1,1 Dichloroethane
- 1,2 Dichloroethane
- 1,1,1 Trichloroethane
- 1,1,2 Trichloroethane
- Methylene Chloride
- Tetrachloroethylene

Organosulfur Compounds

- P-Chlorophenylmethylsulfone
- P-Chlorophenylmethylsulfoxide
- P-Chlorophenylmethylsulfide
- 1,4-Dithiane
- 1,4-Oxithiane
- Dimethyldisulfide

Volatile Aromatics

- Toluene
- Benzene
- Xylene (m-)
- Ethylbenzene
- Xylene (o,p)

DCPD/MIBK

- Dicyclopentadiene
- Methylisobutyl Ketone

DIMP/DMMP

- Diisopropylmethylphosphonate
- Dimethylmethylphosphonate

DBCP

- Dibromochloropropane

Metals

- Mercury
- Arsenic
- Cadium
- Chromium
- Copper
- Lead
- Zinc

Cations

- Potassium
- Calcium
- Magnesium
- Sodium

Anions

- Chloride
- Fluoride
- Sulfate
- Nitrate+Nitrite
- Alkalinity (as $CaCO_3$)

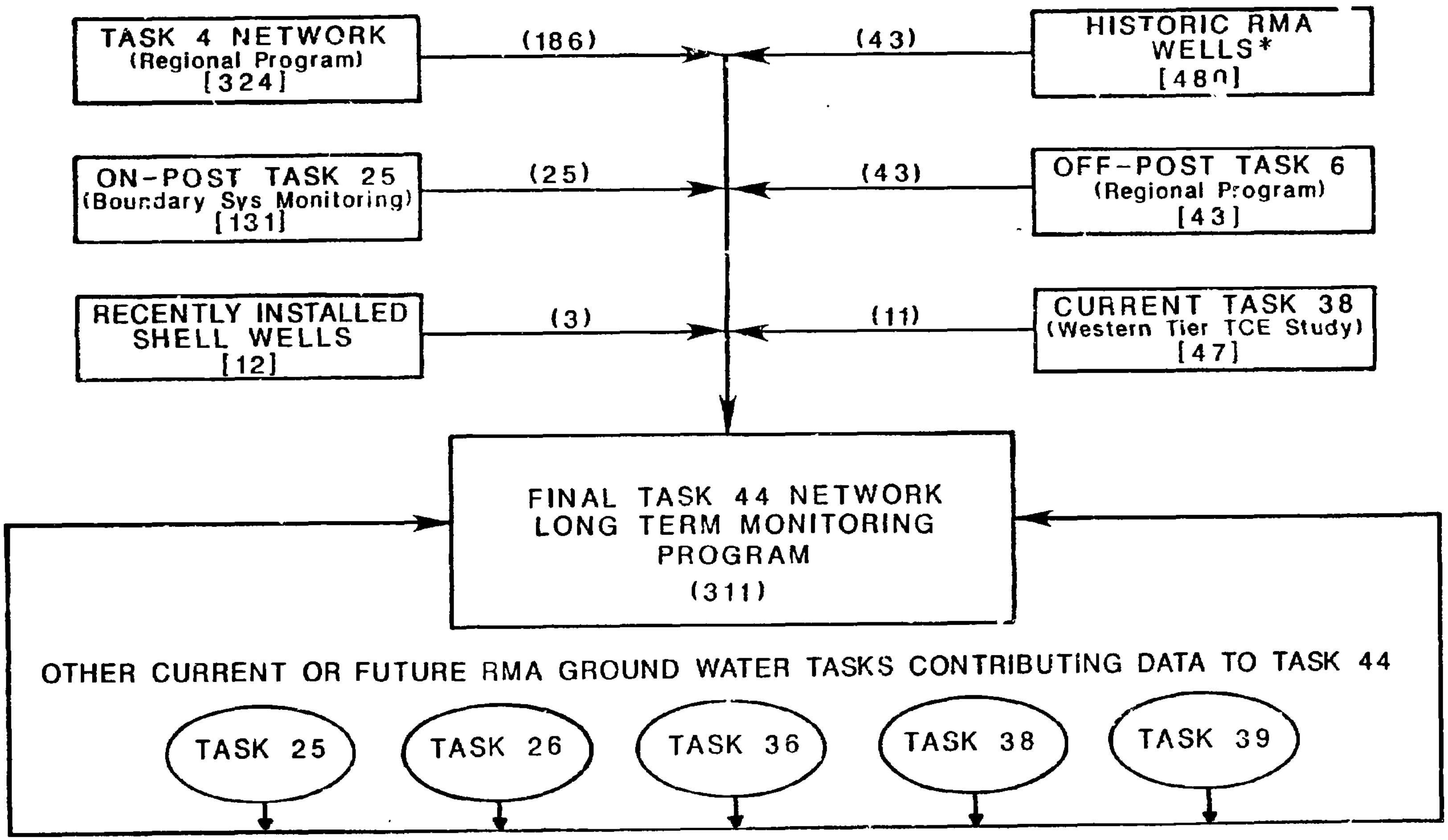
monitoring program will sample a comparable network of wells for a complete suite of target analytes.

VI. CONCLUSIONS

In summary, a Task 44 monitoring well network which consists of 311 total wells has been designed to assess and monitor the distributions of potential contaminants in the alluvial aquifer and in more permeable units within the Denver Formation. This network was designed using water quality and water level information derived from Task 4 as well as data collected by other current or past monitoring programs at RMA.

Considerations which were evaluated in network design include well construction characteristics, sampling history, water quality variability, and location with respect to potential contaminant sites and paleochannels. Emphasis was given to wells which had been included within the Task 4 monitoring program. A higher preference was also given to wells in cluster configurations providing vertically oriented water level and water quality data. Due to the presence of contaminant concentrations above RMA guidance levels in numerous Denver Formation wells, a higher percentage of Denver wells were selected for this program relative to Task 4.

Figure 11 summarizes the well selection process. Of the 324 wells which were sampled under the Task 4 program, 186 remain in the Task 44 network. In addition to these wells, 25 wells were selected from the current Task 25 network, 11 wells were selected from the current Task 38 network, 3 wells were selected from the 12 wells recently installed by Shell, and an additional 43 wells were selected from 480 historical



[ ] Number of wells reviewed
( ) Number of wells selected
*Wells reviewed only in areas where additional coverage was needed

Figure 11
TASK 44 MONITORING WELL NETWORK SELECTION FLOW CHART
SOURCE: HLA, 1987

Prepared for:
U.S. Army Program Manager's Office For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

wells at RMA. In addition to the [illegible]8 on-post wells, the off-post monitoring network consists of 43 monitoring wells. Therefore, a total of 311 monitoring wells are recommended for sampling under Task 44.

The Task 44 monitoring network will be refined and modified as new data are collected. The network was designed with the intent of responding to new data through the addition or deletion of wells to or from the program as geochemical and hydraulic data warrant.

APPENDIX A
COMMENTS AND RESPONSES TO THE
TASK 44 DRAFT LETTER TECHNICAL PLAN
APRIL 29, 1987

The draft version of this Letter Technical Plan was submitted for MOA review on April 29, 1987. Comments were received from the U.S. Environmental Protection Agency on August 28, 1987, the Colorado Department of Health on August 7, 1987, and the Shell Chemical Company on June 22, 1987. These comments and DOA responses are provided in Appendix B of the Task 44 Technical Plan. Comments are an integral part of the review process and are being incorporated in the Task 44 Technical Plan as well as the Technical Plans for the Comprehensive Monitoring Program.

DRAFT RESPONSES TO
U.S. ENVIRONMENTAL PROTECTION AGENCY
COMMENTS TO THE TASK 44
DRAFT FINAL LETTER TECHNICAL PLAN

1. <u>Comment</u>:

Once existing data have been evaluated for recharge/discharge relationships between the Denver Formation and the alluvium, and between surface water and ground water, identified data gaps may necessitate additional wells.

<u>Response</u>:

The Army recognizes that areas needing additional wells to complement the existing well network may be identified as the Task 44 interpretive effort is completed. Recommendations concerning the installation of new monitoring wells will be made as part of the Composite Well Program performed under Task 44.

2. <u>Comment</u>:

As part of the Task 44 objective of integrating all ground water related efforts, two maps containing all active on-post monitoring well locations should be produced. One map should depict Denver Formation Wells, and the other map, alluvial wells. These maps should indicate under which task each well is sampled, and whether the well is monitored for water levels and water quality, or water levels only.

<u>Response</u>:

The two maps described in Comment 2 are currently being produced and will be included in the Task 44 report.

3. <u>Comment</u>:

All evidence indicates that the Basin A neck is one of the most hydrologically complex, and one of the most pivotal to contaminant transport of the sites being monitored on-post. Because it was not discussed in detail in Task 26, nor is it specifically addressed within Task 44, it is uncertain whether the planned monitoring program is adequate to identify the pertinent geologic, hydrologic, and plume migration information. As the interim action for Basin A neck proceeds, the results should be integrated into Task 44. EPA will address possible insufficiencies in the monitoring of the Basin A neck area as comments to the interim action plan.

<u>Response</u>:

Interpretive efforts to be completed under Task 44 will integrate all available water quantity and quality data collected in the Basin A neck

area to perform a thorough data evaluation. This would include data collected under various RMA tasks and historical data. The results of these interpretations will be presented in the final reports. The need for additional monitoring in the Basin A/A neck area is being addressed under the Transition Monitoring Program (TMP) as part of the Comprehensive Monitoring Program. The TMP Monitoring well network includes a total of 15 alluvial wells and 22 Denver wells in the Basin A/A neck area. The TMP will monitor groundwater prior to and after the Basin A neck interim response action is completed.

**DRAFT RESPONSES TO
COLORADO DEPARTMENT OF HEALTH
COMMENTS TO THE TASK 44
DRAFT FINAL LETTER TECHNICAL PLAN**

GENERAL_COMMENTS

1. Comment:

The primary objective of the RMA remedial investigation (RI) is to fully define the nature and extent of contamination in all media at and adjacent to RMA. The objective of Task 44 is to define the nature and extent of ground and surface water contamination caused by the release of hazardous substances, pollutants or contaminants from RMA. Task 44 attempts to consolidate all RMA water monitoring programs. However, as discussed in the State comments on the Task 4 ISP, Task 4 response to comments, Task 25, Task 38, Task 26, Task 39 and the Offpost CAR Report, previous water contamination assessment programs failed to meet the primary RI objective. Therefore, Task 44 should be modified as outlined below:

a. Task 44 must define the nature of contaminants in surface and ground water. Non-target organic contaminants must be identified in water both on and off RMA.

b. Task 44 must evaluate regional and source specific contamination of ground water and surface water.

c. Task 44 must be designed to evaluate the vertical extent of contamination through the Denver Formation and into the Arapahoe formation.

d. Quarterly monitoring of on and offpost wells (and all new wells) should be conducted to expedite the evaluation of the nature and extent of contamination at RMA, to characterize seasonal fluctuation in contaminant concentrations and to closely monitor the effects of remedial activities on the groundwater system.

Response:

(a): The Army agrees that the objectives of Task 44 include assessing the nature of ground-water and surface-water contamination at RMA. This objective was also applied to the preceding regional monitoring ground- and surface-water investigation conducted at RMA (Task 4). Task 4 achieved the stated objective by establishing an analytical program that included analyses for up to 50 target analytes and identification of non-

target analytes using GC/MS methods to analyze waters collected from 10 percent of the wells sampled during the third and fourth quarters of Task 4. Although this objective is not expressly stated in the Task 44 Scope of Work, it will be accomplished under the Task 44 program. The analytical schedule established for Task 44 will include the 50 compounds utilized in Task 4 and benzothiozol. In addition, ground water collected from approximately 10 percent of the on-post and off-post wells sampled under Task 44 will be analyzed using semi-qualitative methods (GC/MS) to screen for 24 purgeable and 25 extractable compounds and to identify non-target analytes. Analytical schedules for future RMA tasks may be revised as non-target analytes are identified.

(b): Expanding the Task 44 Scope of Work to include detailed evaluation of site-specific contamination is not necessary for achievement of the primary objective of the RI stated in Comment 1 above. Task 44 is regional in nature, not a site-specific investigation. However, the Task 44 regional network to some extent utilizes the best existing alluvial and Denver wells for both upgradient and downgradient monitoring of selected contaminant sources. Target and non-target compounds transported from these areas will be identified from the results of Task 44 sampling events. In addition, future long-term monitoring programs will be refined and modified as new data are generated to ensure that adequate geologic, hydrologic, and geochemical interpretations can be made. Program modifications will include the addition and deletion of wells to or from monitoring networks and changes in analyte schedules as needed.

As discussed on Page 1 of the Letter Technical Plan, detailed, site-specific investigations will be completed under Tasks 25, 26, 36, 38, and 39. These tasks must be maintained separate from Task 44 to ensure that the detailed objectives of each task can be accomplished. The results of each of these site-specific tasks will be integrated under Task 44 and will provide additional data for the Task 44 interpretive effort.

(c): The Task 44 network has been designed to provide the data necessary for evaluation of the vertical extent of contamination in the Denver aquifer. The Denver network presented in the Letter Technical Plan (Table 3) was selected by examining concentration levels and depths of contamination reported for existing Denver wells. In general, if a sampled well contained contaminant concentrations in excess of RMA guidance levels, nearby wells completed in vertically adjacent aquifer zones were considered for monitoring. If no existing nearby wells were available for monitoring, recommendations were made for installing new wells at those locations. The maximum depth of contamination will be identified by drilling wells progressively deeper in the Denver Formation. In addition, water-bearing zones within the Denver Formation were considered in terms of hydraulic communication between wells. This information was used as a general indicator of preferred vertical intervals for monitoring.

(d): Quarterly monitoring will not expedite evaluation of the nature and extent of contamination at RMA. Quarterly monitoring either was or is currently being conducted under other RMA ground-water monitoring tasks

(Tasks 4, 25, 26, 36, 38, and 39). The water-quality and water-quantity results obtained under these tasks have indicated that significant seasonal fluctuations are not apparent at RMA and that quarterly monitoring under Task 44 is unnecessary. The need for more frequent monitoring during remediation will be evaluated. Further, semi-annual sampling of a larger number of wells is considered to be a stronger technical approach than quarterly sampling of one-half the wells for determining the nature and extent of contamination at RMA.

2. Comment:

It is difficult to determine the adequacy of the RMA water monitoring programs given that we have not received draft final reports for the Task 4 third and fourth quarters, the Task 4 non-target analyte data and Task 38. Delaying the release to the State of pertinent reports until after the subsequent monitoring programs have been initiated, effectively prevents the State from substantive participation in the ongoing investigations. This has been a consistent practice throughout the RMA water monitoring RI/FS program and does not meet the requirements of Section 121(f) of CERCLA as amended and other applicable State law. These reports and similar contamination assessment reports must be released for review before subsequent water monitoring programs are implemented.

Response:

The State's participation in ongoing investigations has not been intentionally prevented. The timely release of pertinent reports, without compromising data quality, has been and will continue to be a primary objective. The Draft Final Task 4 Report, including third and fourth quarter data and nontarget analyte data (GC/MS), has been completed, and will be submitted in brown cover for MOA review in the near future. The Task 38 final report will also be submitted for MOA review in the near future.

GENERAL COMMENTS BY REGION

I. Western Tier

Comment A: Alluvial aquifer

The extent of the solvent plumes emanating from the motor pool vicinity and other potential source areas on Sections 4 and 9 and migrating through Section 33 have not been fully defined. The Western Tier monitoring program should be expanded by adding monitoring wells 33046, 33047, 33060, 33061, 33015, and 33020 series to the sampling program in the inferred paleochannels on Section 33. Additional monitoring wells in the northwest corner of Section 33 are needed to determine the solvent flux near 77th Street and Quebec.

Response:

The site-specific monitoring of solvent contamination emanating from source areas in the Western Tier (motor pool area) is being conducted under Task 38. Forty-seven alluvial wells have been monitored quarterly as part of Task 38. An additional 16 alluvial wells are included in the Task 44 alluvial monitoring network in the Western Tier (Sections 4, 9, and 33). The analytical results obtained under Tasks 38 and 44 will be combined under Task 44. Of the wells listed in Comment 1A, the Task 38 network includes wells 33046, 33047, 33020, 33022, and 33024. Three wells (33077, 33078, and 33079) recently installed between wells 33015 and 33060/33061 are currently being monitored under Task 38. Additional monitoring wells have been installed in the northwest quadrant of Section 33 and are currently being monitored under Task 38.

Comment B: Bedrock aquifer

Additional Denver aquifer monitoring wells are needed to define the vertical extent of contamination in this area.

Response:

The Army agrees that additional monitoring in the Denver aquifer is needed in the Western Tier. However, additional monitoring will require installation of new Denver wells in this area. The need for additional monitoring in the Denver aquifer has been addressed under the Composite Well Program. However, new Denver wells in this area are considered to be of a lower priority than other wells in the Composite Well Program. Additional monitoring wells will be installed at RMA under the Comprehensive Monitoring Program. The need for new Denver wells in the Western Tier will be re-evaluated at that time.

II. Northwest Region and Boundary (Sections 22, 27, 28, 34, 35)

Comment A: Alluvial aquifer

Additional monitoring wells are needed to fully define the extent of the "newly found" solvent contamination (primarily chloroform) in Sections 34, 35, and 27 and to fully understand how the paleochannels influence the plume. New monitoring wells are proposed to be constructed in Section 34 as part of the Composite Well Program, although the priority of well installation is at issue. These wells must be constructed as "high priority" wells to complete the RI in a timely manner. The lack of monitoring wells in the western part of Section 35 must be addressed in Task 44.

Additional Alluvial aquifer monitoring up and downgradient of the Northwest Boundary Containment System (NWBCS) is needed.

Response:

It is assumed that the "newly found" solvent contamination in Sections 27, 34, and 35 refers to the distribution of organohalogen compounds in alluvial ground water presented in the Draft Final Task 4 ISP Report (October 1986). Contaminant distribution presented in the Final Task 4 ISP Report (August 1987) more accurately depicts the distribution of organohalogen compounds as isolated detections in Sections 34 and 35 and as a potentially continuous distribution extending from southeastern Section 27 to the Northwest Boundary.

The Army agrees that additional monitoring wells are needed in Sections 27, 34, and 35. This need has been addressed under the Composite Well Program and by including three new wells (which Shell recently installed in Section 34) in the Task 44 alluvial network. Well EP65 has been installed under Task 44 in the eastern portion of Section 34 between the two isolated detections of organohalogen contamination. Well sites EP62, EP65, and EP67 have been or are being installed in Sections 34 and 35. The need for additional monitoring in the western part of Section 35 will also be evaluated based on Task 44 results.

The need for additional alluvial aquifer monitoring upgradient and downgradient of the Northwest Boundary Containment System has been addressed by the Composite Well Program under Tasks 25 and 39. Upgradient well sites EP01 and EP01A and downgradient well site E68 have been proposed and given moderate priority. Off-post downgradient sites E55 and E66 have been installed, and on-post sites EP02 and EP03 have been installed in the northwest quadrant of Section 27.

Comment B: Denver aquifer

The Task 4 ISP documented a volatile aromatic contaminant plume in the Denver Formation in Sections 27 and 35. Additional wells are needed to define the nature and extent of this contaminant plume.

Response:

The contaminant distributions presented in the Task 4 ISP Report should not be considered contaminant plumes, as detailed assessments of the geologic and hydrologic conditions present at RMA are necessary before contaminant plumes can be identified. The volatile aromatic distribution in the Denver Formation in Sections 27 and 35 was documented in the Draft Final Task 4 ISP Report (October 1986). This distribution was extrapolated over a distance of approximately one mile between two data points. The revised distribution presented in the Final Task 4 ISP Report (August 1987) more accurately depicts the one volatile aromatic detection in Section 27 as an isolated hit. The need for additional well control in southeastern Section 27 was recognized during design of the Task 44 network. However, only one suitable Denver well (27049) was available for inclusion in the network in this area. Recommendations will be made for the installation of additional Denver monitoring wells in this area.

III. Northern Region and Boundary (Sections 23, 24, 25, 26)

Comment A: Alluvial aquifer

The new wells proposed as part of the Composite Well Program (EP series wells 53, 06, 25, 23, 14, 16, and 13) should be constructed to define the extent of contamination in the Alluvial aquifer beneath the eastern portions of Section 23 and the western portions of Section 24. The wells should be incorporated into Task 44 and included in a quarterly monitoring program for at least one year. Additional monitoring wells are needed in the southwest portion of Section 26.

Response:

Of the EP series wells listed in Comment A above, site EP53 has been installed in southeastern Section 23, sites EP13 and EP14 have been installed in western Section 24, and site EP23 have been installed in eastern Section 23. The remaining wells listed (EP06, EP16, and EP25) are proposed for installation but have been given moderate priority under the Composite Well Program.

Additional monitoring wells are being proposed in the southwestern portion of Section 26. Sites EP44, EP45, EP46, EP47, EP48, and EP59 are proposed for installation in this area. Of these sites, EP47 and EP44 have been completed under Task 19. The remaining proposed sites on this list have been given low priority under the Composite Well Program.

Analytical data obtained for ground-water samples collected before or during Fiscal Year 1987 from each new well will be used in Task 44 interpretations. In addition, future monitoring programs may incorporate any or all of these wells into the regional sampling network.

Comment B: Denver aquifer

New monitoring wells are needed to define the vertical extent of

contamination in this region and to fill the data gaps that exist in the: northwest portions of Section 26; the southwest and western portions of Section 24; and the eastern portions of Section 23 and in the north plants.

Response:

New Denver wells are proposed for installation under the Composite Well Program in each of the areas indicated in Comment B with the exception of the North Plants area. Cluster well sites EP27, EP53, and EP75 have been installed in the eastern-southeastern portion of Section 23. Cluster well site EP74 has been installed in the southwest quadrant of Section 24, and a second Denver sand well has been installed at EP56 in the northwest quadrant of Section 26. The analytical data obtained for the wells installed at each of these locations will be incorporated into the Task 44 interpretive effort. In addition, each new well will be considered for inclusion in future regional ground-water monitoring programs. The need for additional Denver wells in each of these areas will be re-evaluated based on the results of Tasks 25, 36, and 44.

One new Denver well has been installed in the North Plants area under Task 42 and will be considered for inclusion in future regional monitoring networks. The need for additional Denver aquifer monitoring in the North Plants will be re-evaluated based on the results of Tasks 19, 25, 36, and 44.

IV. Central Region (Sections 1, 2, 35, 36)

Comment: Alluvial and Denver aquifers

The Task 44 program will not fully define the nature and lateral and vertical extent of contamination of ground water in Sections 36, 1 and 2. Given this high number of source areas and extensive contamination of groundwater, Task 44 must expand coverage with new and existing wells.

Response:

The need for additional monitoring in Sections 1, 2, and 36 has been recognized and will be addressed by including existing wells and new wells in future regional ground-water monitoring programs. Additional existing wells in the South Plants (Sections 1 and 2) will be included in future regional monitoring networks to provide short-term monitoring for verification of the historical data base. These wells may be included in long-term monitoring networks based on comparison of analytical results to historical data. Eleven new wells are being installed in Section 36 under Tasks 1 and 26. The analytical data obtained for these new wells will be incorporated into Task 44 interpretations, and all new wells will be considered for inclusion in future regional monitoring programs.

V. Eastern Tier

Comment: Alluvial and Denver aquifers

Monitoring well series 19001-005 confirms that multiple chemical contamination exists in the western part of Section 19. New monitoring wells are needed to evaluate the local hydrogeology and the nature and extent of contamination of the eastern tier. Task 44 should also include additional monitoring of the alluvial aquifer in Sections 30 and 31.

Response:

The chemical contamination referred to in Comment V for monitoring well series 19001-005 was reported in the historical USATHAMA data base and has not as yet been confirmed. Monitoring wells 19001 (alluvial) and 19003 (Denver) were included in the Task 44 network, and the analytical results obtained for these wells will be evaluated to confirm the historically reported concentrations. The need for additional monitoring in the southwestern portion of Section 19 will be evaluated based on Task 44 analytical results.

Well 30009 was included in the Task 44 alluvial monitoring network and is the only existing alluvial well of adequate construction for water-quality monitoring in Section 30. EP series EP31-34 are proposed for installation in the western portion of Section 30 but have been given lower priority than other new wells under the Composite Well Program. If installed, these wells will be available for inclusion in a future regional monitoring network. Locations for additional alluvial wells in Section 30 are limited because of large areas of unsaturated alluvium (see Figure 8 in the Letter Technical Plan).

Additional alluvial monitoring in Section 31 would also require the installation of new wells. However, the need for new well installations in this section is considered to be a lower priority than other areas at RMA under the Composite Well Program. If the State is aware of any information which suggests that new wells are needed in Section 31, it is requested that this information be submitted for DOA consideration.

VI. Off-Post

Comment: Alluvial and Denver aquifers

The State has provided detailed comments on the Task 39 offpost monitoring program and the Offpost CAR. State recommendations for improving the offpost monitoring program should be incorporated into Task 44.

Response

The State's comments pertaining to the Task 39 off-post alluvial and Denver aquifer monitoring networks were addressed by identifying specific wells that would be installed to supply specific data requirements. Many of the State's recommendations for improving the off-post monitoring

program were made without complete knowledge of actions that had already been undertaken. For example, the majority of wells installed off-post were not mentioned in the Draft Final Task 39 Technical Plan. The primary concerns addressed by the State were addressed by specifying all off-post installations, many of which were installed under Tasks 36 and 25.

The Task 44 network was designed to meet different objectives than Task 39. Therefore, it is not appropriate to incorporate the Task 39 network in its entirety. The design of the Task 44 network will allow for evaluation of each specific off-post installation for applicability to the regional program and to achievement of specific goals. In this respect, all State comments on the off-post monitoring program will be incorporated into Task 44.

Irrespective of the programs under which data are collected, all available data will be incorporated in Task 44 interpretations.

SPECIFIC COMMENTS

1. Comment:

P.1 The purpose of Task 44 cannot be limited to the design of a long-term regional ground and surface water monitoring program only. The primary objective of Task 44 must be to fully define the nature and extent of contamination of water caused by hazardous substances, pollutants, and contaminants at RMA. Task 4 initiated this effort. Task 44 attempts to consolidate all earlier water monitoring efforts. As the State indicated in its comments on the Task 4 ISP Report, the Task 4 Draft Response to Comments, the Offpost CAR, and Task 39, there are many areas where previous water contamination assessment programs did not meet the statutory and regulatory objective of defining the nature and extent of contamination.

Response:

Please refer to General Comment 1 and our response to that comment. It is clear in both the comment and response that the purpose of Task 44 is not limited to the design of a long-term regional ground- and surface-water monitoring program.

2. Comment:

Limiting Task 44 to regional groundwater monitoring will not provide sufficient information to identify active sources, contaminant transport mechanisms and individual plume pathways. Saturated zone contaminant investigations at specific source areas are needed to identify "active" source areas; to define the interaction between unsaturated and saturated zone contamination; and to determine the extent and type of remediation needed for specific sources to effect a complete cleanup of the RMA.

Response:

The Task 44 network was not designed to provide monitoring around site-specific or potentially active source areas. Site-specific investigations are being provided under Tasks 25, 26, 36, 38, and 39 and in other Phase II soils tasks as outlined in the Letter Technical Plan. The analytical results obtained from all RMA ground-water monitoring tasks will be integrated under Task 44 to provide assessment of contaminant transport mechanisms and migration pathways. The complete integration of soils and ground-water data will be completed under the guidance of Task 23.

3. **Comment:**

P.1 Task 44 should not be limited to utilizing data and evaluations within the Army's designated offpost study area. The U.S. EPA, SACWSD and the Tri-County Health Department are generating water quality and quantity data south of 80th Avenue to 56th Street and between the RMA west boundary and Monaco Street. These data must be incorporated into the evaluations of the nature and xtent of a groundwater contamination on and off RMA.

Response:

Data generated by the U.S. EPA, SACWSD, and the Tri-County Health Department in off-post areas adjacent to RMA will be incorporated into the Task 44 water quality and quantity evaluations as it becomes available.

4. **Comment:**

P.2 The Task 4 ISP sampled 310 wells for water quality. However, none of these samples were analyzed by GC/MS techniques to identify the full spectrum of organic contaminants present in the groundwater. To correct this oversight, one in ten of the Task 4 third and fourth quarter samples were analyzed by GC/MS for non-target analytes. Although these samples were collected over one year ago and despite our repeated requests for the information, these data have not been released for review. It is not possible to evaluate the appropriateness of the "target analyte" list or the RMA groundwater monitoring programs without this information.

The number of monitoring wells sampled in subsequent quarters of Task 4 was reduced from 320 to 188 wells. Therefore, the groundwater monitoring program attempts to identify the complete spectrum of organic contaminants at a 27 square mile facility with approximately 88 contaminant source areas based on approximatel 38 samples. The nature of groundwater contamination at R[illegible] accurately evaluated with so few samples. Depending on which [illegible] selected, the data collected could substantially dist[illegible] [illegible] of contaminants present in the surface and groundwater [illegible] RMA

The evaluation of the nature of contaminants in the groundwater must also be site/source specific to define the types of contaminants being released from individual source areas.

Response:

Non-target GC/MS analytical data for the third and fourth quarters of Task 4 will be included in the Task 4 Final Report and copies have been submitted for MOA review at the October 16, 1987 meeting at the Denver offices of ESE. Some limited source-specific monitoring will be conducted as part of Phase II soils tasks, existing ground-water monitoring tasks, and the long-term comprehensive monitoring program. The locations of alluvial and Denver wells from which samples were collected for GC/MS analysis during Task 4 are presented in Figures 1 and 2. As shown in these figures, GC/MS analyses have been performed on many of the wells

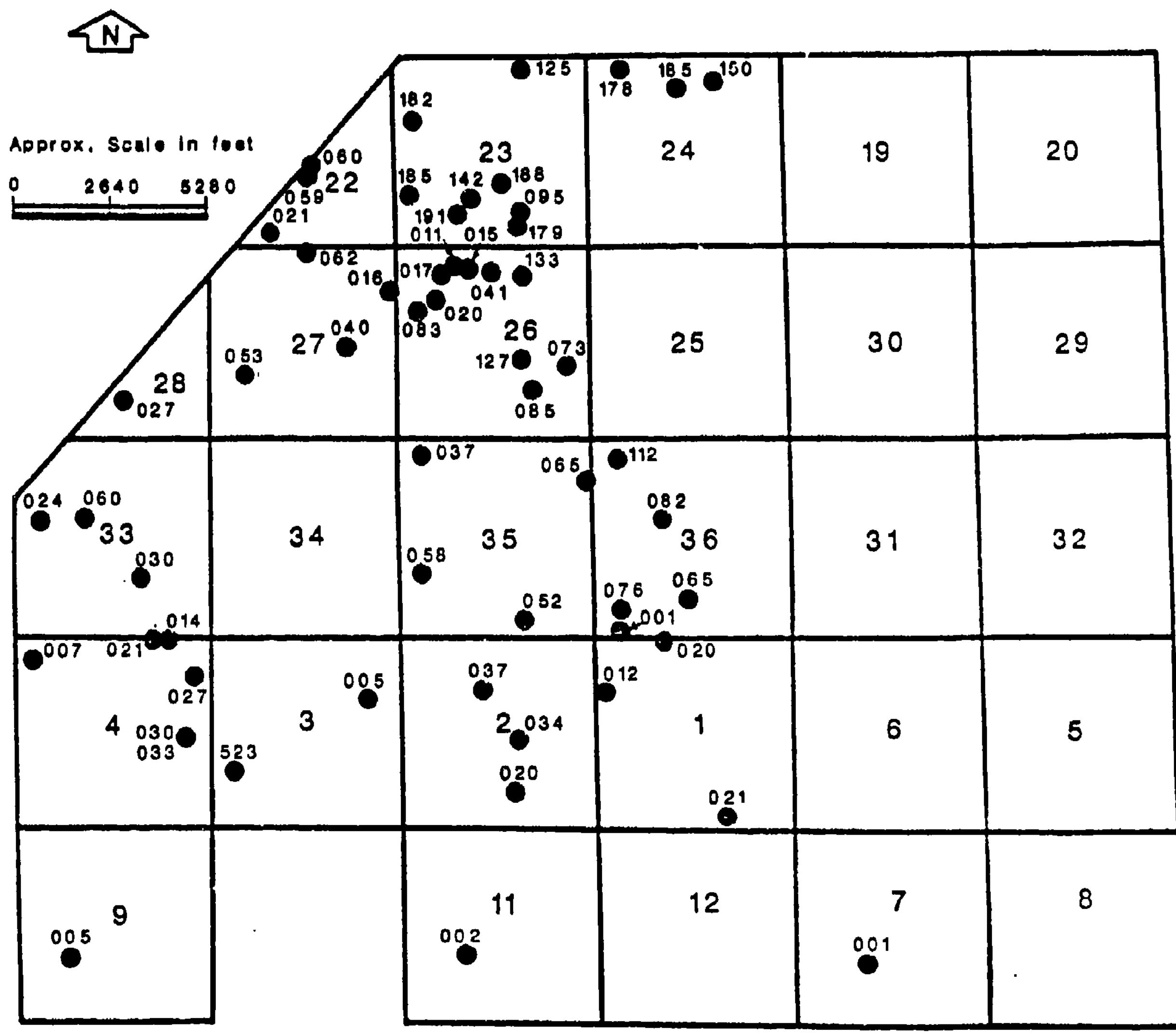


Figure 1
TASK 4 ALLUVIAL WELLS SAMPLED FOR GC/MS ANALYSIS DURING THE THIRD OR FOURTH QUARTER (FY 86)

Prepared for:
U.S. Army Program Manager's Office For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

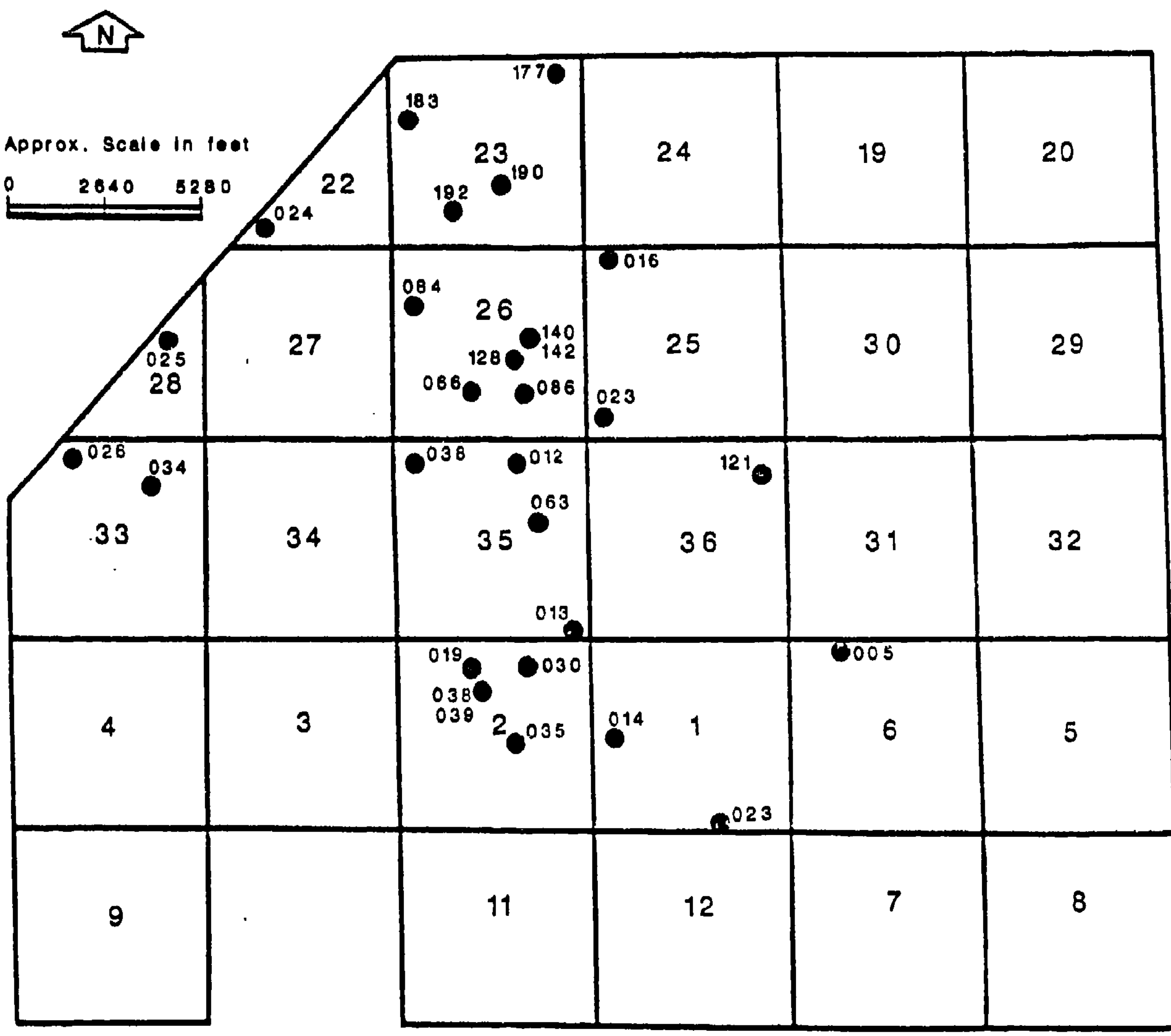


Figure 2
TASK 4 DENVER WELLS SAMPLED FOR GC/MS ANALYSIS DURING THE THIRD OR FOURTH QUARTER (FY 86)

Prepared for:
U.S. Army Program Manager's Office For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

located in and around the major source areas at RMA. At least 10 percent of the samples collected under the long-term monitoring program will continue to be analyzed using GC/MS techniques.

5. **Comment:**

P.3 The fourth objective of Task 44, identifying areas of significant public health exposure, is inappropriate and should be deleted from the task. Task 35, the RMA Endangerment Assessment, should evaluate all pathways of public health exposure on and offpost, including those associated with groundwater contamination. Contaminated drinking water is only one exposure pathway that must be assessed to define areas of significant public health exposure.

Response:

The fact that the objective of identifying areas of significant health exposure was included in Task 44 should not be construed to imply that a complete assessment of public health exposure will not be performed under the endangerment assessment (Task 35). Because Task 44 covers areas both on and off RMA, data are being collected in areas where public exposure to contaminated water could occur. The data generated in these areas will be provided as input to Tasks 35 and 39 where a determination of public health exposure will be made.

6. **Comment:**

P.3 Task 44 cannot meet objectives five and six using only available or existing geologic and hydrologic data. Task 44 should generate geologic and hydrologic data from the Alluvial, Denver, and Arapahoe formations. The stated objectives should be modified accordingly.

Response:

The use of "available data" refers to existing data as well as geologic and hydrogeologic data currently being generated under Tasks 25, 36, 39, and 44.

7. **Comment:**

P.3 The difference between the first and seventh objective is not clear. If "aqueous media" means surface water, it should be clearly stated. The nature of contaminants must also be evaluated.

Response:

The term "surface water" will be added to the first objective. The seventh objective will be amended to read "identify the primary hydrologic pathways by which contaminants are being transported to the RMA boundary or the off-post area" in the forthcoming Task 44 Technical Plan. As discussed in General Comment 1(a), the nature of contaminants will be addressed under Task 44.

8. Comment:

P.3 The eighth objective of Task 44 appears to duplicate Task 23. Although a Task 23 Technical Plan has not been prepared for review, the stated purpose of Task 23 is to define the interaction between contaminated soils and contaminated water. Please clarify the differences between Tasks 44 and 23 in both draft technical plans. Unless there is a substantive difference between the tasks, the effort should be conducted in Task 23 to avoid duplicative assessments.

Response:

The differences between Tasks 44 and 23 will be clarified in both task Technical Plans. Task 44 is the data collection task, and Task 23 is the interpretive task under which the interaction between soil and water will be evaluated. Data will not be collected under Task 23. Data collected under Task 44 will be used to supply appropriate information to the Task 23 efforts including data bases, contaminant distribution maps, and geologic and hydrologic assessments.

9. Comment:

P.5 The proposed groundwater monitoring network for the offpost areas is insufficient. Please refer to the State comments on the Offpost CAR and Task 39 Technical Plan for specific deficiencies.

Response:

As described in the response to General Comment VI, the majority of wells being installed off-post were not described in the Draft Final Task 39 Technical Plan. The deficiencies outlined by the State for the Task 39 program are being addressed by the Composite Well Program and the installation of new monitoring wells under Tasks 25, 36, and 39. The wells being installed off-post will be sampled under their respective tasks and then considered for inclusion in future RMA regional monitoring networks. Data collected under each of the various ground-water monitoring tasks will be integrated under Task 44.

10. Comment:

P.6 The Army has identified the Alluvial, Denver, and Arapahoe aquifers as being "of primary concern." However, Task 44 does not propose any monitoring of the Arapahoe aquifer and proposes only limited monitoring of the Denver aquifer in the offpost areas. Additional monitoring of the Denver and Arapahoe aquifers is needed.

Response:

The Arapahoe Formation has been identified as one of the stratigraphic units of primary concern off-post in that the Arapahoe aquifer is used as a primary drinking water source in the Denver area. However, there is no

indication that this aquifer has been contaminated; therefore, it is not necessary to extend monitoring to the Arapahoe. The vertical extent of contamination in the Denver aquifer is being assessed under Task 44 and data from this effort will be utilized to evaluate the potential for deeper contamination.

The Task 44 off-post monitoring network includes all existing wells not currently being sampled under other RMA tasks (Tasks 25, 36, and 39). Additional off-post Denver wells are being installed under Tasks 36 and 39 as directed by the Composite Well Program. All existing and new wells under Tasks 25, 36, and 39 will be available for inclusion in future long-term monitoring networks. Analytical results from each of these tasks will be incorporated in the Task 44 interpretive effort.

11. Comment:

P.7 Low yield monitoring wells should not be automatically eliminated from the Task 44 well network. Low yield may be a function of formation permeability, not improper well construction. The bedrock formations will have a comparatively lower permeability than the Alluvial formations. However, the bedrock formations may still present a significant environmental pathway for RMA contaminants.

Response:

Low yield wells were not automatically eliminated from the Task 44 network. Only those wells which consistently did not recharge sufficiently within a 24-hour period and thereby could not be sampled according to USATHAMA procedures were not considered for inclusion in the Task 44 network. Low yield wells sampled in the past were given equal consideration with other available RMA wells.

12. Comment:

P.7 Wells with unacceptable and questionable construction are being used to evaluate the nature and extent of groundwater contamination. Using poorly documented or constructed wells could result in misinterpretations of groundwater conditions and may not provide an accurate definition of the extent of vertical contamination. Task 44 and "long term monitoring programs" must replace "unacceptable and questionable" wells with properly constructed and documented wells to the maximum extent possible.

Response:

The Army does not agree that the wells classified as questionable will yield inaccurate results. All wells considered adequate for sampling were classified as acceptable, potentially acceptable, and questionable based solely on the amount of supplemental construction information available. Therefore, there is no reason to suspect inaccurate results from any wells classified as questionable.

We agree that using unacceptable wells could lead to misinterpretation of ground-water conditions and may not provide an accurate definition of the extent of vertical contamination. Attempts are being made to replace unacceptable wells located in critical areas with new, properly constructed wells. Eight wells considered to be of unacceptable construction for monitoring are included in the Task 44 network. Six of the wells (23095, 23108, 26015, 26017, 26020, and 27016) are Basin F monitoring wells which have been monitored historically and are being sampled to develop and maintain a chemical data base. As discussed in the final Task 4 ISP Report (August 1987), a proposal was made to replace these six wells with nine existing wells which had been evaluated and found to be adequate for water-quality monitoring; however, the deletion and replacement of the six wells was deemed premature by the CDH and the U.S. EPA. The two remaining isolated wells (26006-Alluvial and 05001-Denver) were selected based on their location and screened intervals. New alluvial wells are proposed for installation at sites EP44, EP45, and EP46 in the vicinity of Well 26006. New wells have been considered around Well 05001, but this area has been given lower priority than other areas at RMA under the Composite Well Program.

13. Comment:

P.8 Using unilaterally established "water quality guidance levels" as a screening criteria for incorporating wells into the Task 44 network is inappropriate. The primary objective of Task 44 must be to fully define the nature and extent of contamination at RMA, not the extent of contamination "above Army guidance levels." All references to this criteria should be deleted from the technical plan. The well network should be reevaluated to include sufficient wells to meet the primary objective.

Response:

Guidance levels were used as one of several screening criteria for incorporating wells into the Task 44 monitoring well network. Specifically, guidance levels were used only to prioritize well locations. No wells were removed from further consideration based solely on guidance levels. Guidance levels were selected consistant with water-quality criteria; however, if no water-quality criteria were available then guidance levels were established to correspond to either analytical detection limits or levels suggested by CDH or the Army. Therefore, the use of guidance levels in designing the Task 44 well network could not have negatively impacted the Task 44 program.

14. Comment:

P.9 The evaluation of the Task 44 well network should emphasize the location (areal and vertical) of a well rather than the recency of water quality data. The variation of analytical results should not be used as a criterion for incorporating wells into Task 44.

Response:

Well location (areal and vertical) was given preference over the recency of water-quality data, with all other selection criteria being equal during formulation of the Task 44 network. However, preference was given to wells with recent water-quality data when selecting between wells close to one another.

We disagree that variations in analytical results should not be used as well selection criteria. The consistency of analytical results is an important criteria in assessing historical water-quality data and thereby influences the well selection process.

15. Comment:

P.10 The rationale for well selection in the Denver Formation fails to recognize that "downgradient" flow is likely to be vertical, as well as horizontal. The monitoring program should be modified accordingly.

Response:

As discussed on Page 13 of the Letter Technical Plan, the rationale for well selection in the Denver Formation recognized the need to evaluate the required maximum depth of monitoring. In general, if a sampled well contained contaminant concentrations in excess of RMA guidance levels, nearby wells completed in vertically adjacent aquifer zones were considered for monitoring. If no nearby wells existed or were screened in the appropriate zone, installation of a new well was considered under the Composite Well Program. The discussion presented on Page 10 and referenced in Comment 15 addresses only the issue of lateral extent of contamination.

16. Comment:

P.11 A comparison of Figures 5 and 9 indicates that the paleochannel map was prepared using excessive extrapolation. For example, Figure 9 shows three separate northwest trending channels beneath Sections 4 and 9 based on two data points (09002 and 09005) within a "channel." There is not a single data point in the northernmost channel (shown to extend for 1-1/2 miles). Similarly, in Section 3 and other areas where paleochannels are shown, little or no data exists to establish the location and orientation of the channels. The Task 44 program should not be focused on "inferred" or imagined channels. The monitoring well network and these figures should be modified accordingly.

Response:

Inferred bedrock paleochannels were not constructed based on the data points (well locations) shown on Figure 9. As stated on Page 11 of the Letter Technical Plan, the paleochannel map was prepared from available geologic information. This information included boring logs, bedrock contour maps, and alluvial thickness maps. Therefore, the locations of

the paleochannels shown in Figures 5 and 9, developed from existing geologic data, represent reasonable estimates for major ground-water migration pathways at RMA.

17. Comment:

P.12, 13 The Denver Formation monitoring network design does not provide an adequate mechanism to determine the extent of vertical contamination in areas where there are limited Denver aquifer monitoring wells. Vertical cluster wells must be constructed into the Arapahoe formation.

Response:

A "phased approach" has been taken to determine the vertical extent of contamination. In this approach, wells are drilled progressively deeper in the Denver Formation to determine vertical contaminant occurrence rather than immediate drilling to the Arapahoe Formation. By conducting the investigation in this manner, the deepest contaminated interval can be determined while minimizing the risk of cross- contamination. As an example, this rationale was used in proposing a new well cluster at site EP56 in north-central Section 26, where primary priority has been given to an alluvial well and a first Denver sand well under the Composite Well Program. The analytical results obtained for ground-water samples collected from these wells will be used to determine whether a second Denver sand well proposed under the Composite Well Program at site EP56 will be drilled. This procedure will be continued at site EP56, and other sites, until the vertical extent of contamination has been adequately defined.

18. Comment:

P.12 Figure 6. Regional and localized groundwater flow should not be represented using subjective arrows that appear to identify the locations of the three operating boundary systems. A potentiometric surface contour map would be more useful to demonstrate the uppermost groundwater flow directions.

Response:

The ground-water flow directions presented in Figure 6 were drawn based on previous hydrogeologic investigations (May 1982) and on recent water-table contour maps (Task 4). A map showing ground-water flow directions and water-table contours will be presented in the Task 44 Technical Plan.

19. Comment:

P.13 The Task 44 monitoring program must design a Denver aquifer monitoring program based on the geologic/hydrogeologic units of the Denver Formation. The present program, as well as the interpretations in the Task 4 ISP Report, are incapable of determining contaminant pathways in the complex sandstone and shale/claystone units.

Detailed stratigraphic interpretations of the Denver Formation throughout RMA are necessary components of the Task 44 investigation. These geologic interpretations should be used to revise the present Task 44 Denver monitoring well network; to better define contaminant pathways; and to define the vertical and areal extent of contamination.

Response:

As presented in the MOA meeting held in Denver from August 31 to September 3, 1987, detailed stratigraphic interpretations of the Denver Formation have been completed or are being completed for selected portions of RMA. Geologic and hydrologic information is currently being integrated under Task 44 to assess contaminant pathways and to define vertical and lateral contaminant distribution. Task 44 assessments will be used to recommend strategies for Denver aquifer monitoring in future RMA groundwater investigations.

20. Comment:

P.14 The report should describe the criteria used to classify a well as a "Denver" well. Previously, all wells with screened intervals within 10 feet of the Alluvial/Denver interface were identified as Alluvial wells. This criteria should continue to be applied to Task 44.

Response:

The rationale used to classify wells as alluvial or Denver during Task 4 was based on an alluvial/Denver interface arbitrarily selected at 10 feet below the alluvium/Denver Formation contact. The interface was established as the assumed depth below which the Denver aquifer could be considered a discrete hydrogeologic unit isolated from the overlying alluvial aquifer. The depth to the interface was arbitrarily selected because no geologic or hydrogeologic interpretations were included under the Task 4 guidelines. However, the interpretive efforts under Task 44 will facilitate identification of discrete water-bearing zones and, therefore, an arbitrarily selected alluvial/Denver interface may no longer be appropriate. As a result, wells were selected for inclusion in Task 44 alluvial and Denver monitoring networks based solely on the locations of screened intervals with respect to reported locations of the alluvium/Denver Formation contact. All Task 44 data will be evaluated and interpretations will be made according to discrete water-bearing units.

21. Comment:

P.14 Quarterly sampling should be continued for onpost wells until the RMA monitoring program has successfully defined the nature and extent of groundwater contamination at RMA. Seasonal fluctuation and anomalous data will not be identified using a semi-annual monitoring schedule. After the primary objective of Task 44 has been achieved, a "long term", semi-annual monitoring program may be appropriate.

Response:

Please refer to our response to General Comment 1(d).

22. **Comment:**

P.17 The Task 44 Denver well network should not be limited to existing wells. New Denver and Arapahoe formation wells are needed both on and offpost to evaluate the vertical extent of contamination.

Response:

The well networks for Task 44 and future regional monitoring programs are designed to be dynamic, and newly installed wells may be added to the networks if information from these wells would help achieve task objectives. Information generated from other RMA tasks will be incorporated into the Task 44 interpretive efforts. Recommendations for new wells will be made following Task 44 assessments.

23. **Comment:**

P.19 The three "major hydrologic zones" proposed to describe the Denver Formation apply only to the South Plants/Basin A area. These zones should not be construed as "hydrogeologically continuous" on an Arsenal-wide scale. Until the detailed hydrogeologic interpretation of this task is completed, such conclusions are premature.

Response:

The Army agrees that the three major hydrologic zones discussed on Page 19 of the Letter Technical Plan should not be construed as hydrogeologically continuous across RMA. Specific references to Denver lithologic units will not be included in the Task 44 Technical Plan, but evaluation and correlation of these units is being conducted under Task 44 and will be discussed in detail in the Task 44 Final Report.

24. **Comment:**

P.20 Non-target GC/MS analyses must be continued both on and offpost to characterize the types of contaminants present in the ground and surface water at the principal source areas.

Response:

Approximately 10 percent of the samples collected on-post and off-post under Task 44 will be analyzed using GC/MS methods. These methods will be used to screen for 24 purgeable and 25 extractable compounds and to identify non-target analytes. This information will be documented in the complete chemical analysis discussion presented in the Task 44 Technical Plan.

DRAFT RESPONSES TO
SHELL CHEMICAL COMPANY
COMMENTS TO THE TASK 44
DRAFT FINAL LETTER TECHNICAL PLAN

1. Comment:

The alluvial well distribution is very sparse in the South Plants, Basin A, and eastern reach of Basin A Neck paleochannel. Both South Plants and Basin A are primary source areas, and the Basin A Neck is a principal pathway. Why are there so few wells in these areas? In addition, there is a paucity of wells along one of the demonstrated flow paths from the Basin F/chemical sewer area in Section 26 to the North Boundary (common boundaries of Sections 23 and 24). These points are well illustrated by Figures 8 and 9, in which the alluvial well network overlies a map of the saturated alluvial areas and principal paleochannels, respectively. Note the lack of wells in Basin A, Basin A Neck and Basin F-North Boundary channels.

Response:

As discussed on Page 1 of the Letter Technical Plan, the Task 44 well network was formulated to provide regional ground-water monitoring in on-post and off-post areas at RMA. Well networks for five additional ground-water tasks (Tasks 25, 26, 36, 38, and 39), as well as some Phase II soil sampling tasks, have been established to provide monitoring in specific investigative areas such as the boundary systems, primary source areas, and/or potential migration pathways. The area along the common boundary between Sections 23 and 24 is within the Task 25 investigative area. The Task 25 program includes quarterly monitoring of existing and new wells. All available analytical results obtained from all site-specific RMA ground-water monitoring tasks will be integrated with Task 44 results under the interpretive effort to be completed under Task 44. As such, the number and location of monitoring wells included in the Task 44 network in the areas indicated in Comment 1 is sufficient and in accordance with the Task 44 objectives; however, the Army agrees that additional verification of the historical data base in the South Plants area is necessary. The Army recently received a number of logs for Shell wells which previously were not available. The logs are being assessed to determine the acceptability of these wells for sampling, and some of these wells will be incorporated into the well network for the comprehensive long-term sampling program. In addition, any data resulting from sampling and analysis programs conducted by Shell will be used to supplement Army data.

2. Comment:

The contaminant migration pathway from the Basin A Neck paleochannel and the Section 26 basins to the Northwest Boundary has not been adequately defined. More wells, both alluvial and Denver are needed to

establish hydrogeologic definition in this area (principally in Section 27).

Response:

More wells have been installed and are being installed in this area to establish hydrogeologic definition. Alluvial and Denver wells have been installed at sites EP44 (Section 26), EP47 (27084), EP49 (Section 26), EP52 (Section 26), EP53 (23220, 23221, 23222), EP54 (26148) and EP56 (26153). Sites EP45, EP46, EP48, EP50, and EP56 in Section 26 may be installed but are of secondary priority under the Composite Well Program. Data from these wells will be incorporated into the Task 44 interpretation as they become available.

3. Comment:

The Denver Formation network appears to be biased in the areal distribution of wells. There are 12 wells monitoring East Section 22 and West Section 23. Data reviewed to date does not suggest that this area needs extensive monitoring. There are only 4 wells in Section 27 which is an area known to have significant contamination. Also, we need a better understanding of any pathway to the Northwest Boundary through this section. We need more wells to build our understanding of Section 27.

Response:

The Task 44 Denver well network was selected from existing wells of suitable construction for water-quality monitoring. Therefore, any apparent bias in the Denver well network is a function of the lack of availability of existing and adequately constructed Denver wells. New, properly constructed wells are currently being installed under various ground-water monitoring tasks at RMA. The overall coordination of new well installations is directed by the Composite Well Program. New wells installed under tasks other than Task 44 will be sampled twice under their respective tasks and will then be considered for inclusion in future long-term monitoring networks. However, the analytical results of all wells sampled at RMA will be integrated under the Task 44 interpretive efforts. The 12 wells monitoring east Section 22 and west Section 23 were included in the Task 44 network to provide vertical definition of contamination in the Denver aquifer. Two of these wells (23182 and 23185) are screened in the upper portion of the Denver Formation and were included to provide monitoring of water table conditions beneath unsaturated alluvium.

The Army agrees that additional Denver wells are needed in Section 27 to assess potential ground-water migration pathways to the Northwest Boundary through this section. However, the number of wells included in the Task 44 network in Section 27 is again a function of the number of existing Denver wells of suitable construction for monitoring. Additional monitoring of the Denver aquifer in Section 27 is provided

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The statement made by Shell that the existence of a "major" flow path from Basin A through the Basin A Neck to the southwest corner of Section 26 is much more important than that trending from Basin A north through Basin C is not necessarily true. The fact that there are higher concentrations of contaminants at the north boundary suggests that the north trending flow path from Basin A should not be discounted as a potential contributor of contamination to the northern area and considered of less importance than the northwest trending flow path extending from Basin A to the southwest corner of Section 26. Also, although the rate or volume of water movement from Basin F to the North Boundary may not be as high as that in other areas of RMA, this is a contaminant pathway and is therefore a flow path that needs to be considered.

6. <u>Comment</u>:

More wells are needed offpost to the east and south to more accurately establish upgradient "background" water quality.

<u>Response</u>:

After assessing the analytical results of samples from numerous upgradient wells during Task 4, background water- quality sampling points were revised to reflect conditions immediately upgradient of observed ground-water contaminant distributions. Background wells were established as close as possible to contaminant distribution boundaries in order to describe any potential degradation of water quality in a timely manner. The current Task 44 well network along the southern and eastern tier is thought to adequately monitor influent alluvial and Denver water quality. The need for additional background wells was evaluated as a part of the Composite Well Program; however, such wells are considered to be a low priority compared to other proposed wells in the Composite Well Program.

7. <u>Comment</u>:

As defined in Task 4, the Army's designation of wells as "alluvial" or "Denver" is open to question. No mention of these criteria is made in Task 44, so it is assumed the same rules apply. A discussion regarding the rationale behind the Army formation designation is required to resolve this issue.

<u>Response</u>:

The rationale used to classify wells as alluvial or Denver during Task 4 was based on an alluvial/Denver interface arbitrarily selected at 10 feet below the alluvium/Denver Formation contact. The interface was established as the assumed depth below which the Denver aquifer could be considered isolated from the overlying alluvial aquifer. The depth to the interface was arbitrarily selected because no geologic or hydrogeologic interpretations were included under the Task 4 guidelines. However, the interpretive efforts under Task 44 will

facilitate identification of discrete water-bearing zones and, therefore, an arbitrarily selected alluvial/Denver interface is no longer necessary. As a result, wells were selected for inclusion in Task 44 alluvial and Denver monitoring networks not by using the arbitrarily selected 10-foot rule but based solely on the locations of screened intervals with respect to reported locations of the alluvium/Denver Formation contact. However, all Task 44 data will be evaluated and interpretations will be made according to discrete water-bearing units.

8. Comment:

The Havana surface water detention pond in the southeast corner of Section 11 may be collecting grease and other contaminants from offsite. The contaminated surface water in the pond may be leaching to groundwater and serve as a contamination source. To characterize this potential source, additional wells need to be placed both upgradient and downgradient of the pond. In addition, the water in the detection pond needs to be sampled to determine contamination.

Response:

The investigation of upgradient, off-site contaminant sources located on the Peoria Interceptor would best be investigated through an investigation of surface-water quality and sediment composition. Chemical characterization of surface water and sediment, in conjunction with revision of the surface water analysis at Havana Pond, will serve to quantify surface-water flux and contaminant flux to the ground-water system. Identification of significant contaminant fluxes would then require re-evaluation of the need for additional monitoring wells in this area. This assessment is not included in the Task 44 scope of work, but recommendations to initiate this investigation may be made following Task 44 evaluations.

9. Comment:

Objective #7 (p. 3) cannot be met without additional wells in the Denver formation, especially Section 27.

Response:

Wells have been installed at Sites EP02 and EP03 under Task 25 and will aid in defining contaminant distribution at the Northwest Boundary. Data from several sources, including Tasks 25, 26, 36, 38, 39, and Shell interpretations, will be integrated with Task 44 data and will provide a comprehensive data base for Task 44 interpretations.

10. Comment:

Page 5, Paragraph II

- Why is Task 6 not used as input to Task 44 in Figure 1?

- Are any of these wells considered questionable? If so, why not drill new wells?

- In the complete plan there should be a description of all the Denver wells and the logic for their inclusion in the program.

Response:

(a): Figure 1 presents the relationship of current, ongoing, detailed ground-water studies to Task 44. Task 6 refers to a different USATHAMA contract (DAAK11-83-D-0007) for off-post contamination assessment. This task is no longer an ongoing RMA program because all previous Task 6 wells have been transferred to Task 44. Therefore, Task 6 is not included in the diagram present in Figure 1. Similarly, Task 4 is also not listed in Figure 1.

(b): Twenty-nine of the 43 wells included in the Task 44 off-post monitoring network were installed during the Fall of 1985 under Task 6. All of these wells were installed using proper well construction procedures and are considered acceptable for water-quality monitoring. The remaining 14 off-post wells include 4 domestic wells and 10 wells installed by the Army prior to 1985. All of these remaining wells are considered to be of adequate construction for water-quality monitoring, with the exception of Well 37305 which was abandoned and replaced with a new well installed under Task 36. This new well (37370) will be available for future long-term monitoring networks.

(c): A table summarizing the rationale used in selecting each well for the water-quality network will be included in the Task 44 Technical Plan.

11. **Comment:**

Page 5, Paragraph III

- Are any of the existing wells unacceptable? If so, new wells must be drilled and utilized in place of the unacceptable wells.

- The existing wells will not evaluate potential pathways in the Denver formation unless there are additional wells not described herein.

- Shell will provide recommendations on locations of proposed Denver formation wells once the information requested in No. 4 above is supplied.

Response:

(a): Eight wells designated as unacceptable are included in the Task 44 on-post water-quality monitoring network. Six of these wells have been monitored historically under the Basin F Monitoring Program;

therefore, they will continue to be monitored under Task 44 to maintain a consistent data base for this program. As discussed in the Final Task 4 ISP Report (August 1987), a proposal was made to replace these six wells with nine existing wells which had been evaluated and found to be adequate for water-quality monitoring; however, the deletion and replacement of the six wells was deemed premature by the CDH and the U.S. EPA. The two remaining unacceptable wells (26006-alluvial and 05001-Denver) were included in the Task 44 network based solely on the need for monitoring in their respective locations. New alluvial wells are proposed for installation at sites EP45, and EP46 and have been installed at Site EP44 in the vicinity of Well 26006. New wells have been considered around Well 05001, but this area has been given lower priority than other areas at RMA under the Composite Well Program.

(b): The locations of potential pathways in the Denver Formation will be assessed as further geologic and hydrogeologic interpretations are completed under Task 44. These interpretations will be made by incorporating data obtained from site-specific tasks (Tasks 25, 26, 36, 38, and 39) with data collected under Task 44. Therefore, data obtained from the Denver monitoring network presented in the Letter Technical Plan will be supplemented with data collected from additional Denver wells being monitored under the various site-specific tasks.

(c): Shell's recommendations on locations of proposed monitoring wells will be given consideration under the Composite Well Program along with locations recommended by the DOA and its contractors.

12. Comment:

Page 5: The offpost Denver Formation monitoring well discussion is unclear. How many Denver wells will there be and what are their locations? If there is only one (as stated), the proposed network is inadequate.

Response:

Only one Denver well was included in the Task 44 off-post network, as all other off-post Denver wells are being sampled under other RMA tasks (36, 39, and 25). Data from these sampling efforts will be incorporated into Task 44 interpretations.

Presently, 12 new Denver wells have been installed downgradient of the North Boundary Containment System under Task 36. Eight of these wells are off-post. These eight wells were completed as cluster sites to assess the vertical potential for contaminant migration and the water quality of the uppermost Denver Formation. The preliminary water quality and hydrologic data from these wells is being used to determine the need for deeper wells and/or wells completed further downgradient. The Army agrees that additional off-post Denver monitoring wells are needed in the regional monitoring program; therefore, the new off-post installations and additional sites being considered will all be

evaluated for inclusion in the comprehensive long-term monitoring program.

13. Comment:

Page 6, top of page: If Task 44 is to be an integration task, why aren't all the wells from other tasks incorporated? If the other task results are to be incorporated, the sampling of the wells in the other tasks must also be coordinated. Wouldn't it be easier if all the wells were included within this task, rather than having to coordinate all the other task results?

Page 6, second paragraph: How was the priority rank assigned? What criteria and scoring were employed?

Response:

(a): The Task 44 network has been designed as the basic framework by which the objectives presented in the Delivery Order for Task 44 (see Pages 2 and 3 of the Letter Technical Plan) can be achieved. The integration of all ground-water related tasks is included as an additional objective (or secondary objective) of Task 44. The Task 44 network was formulated such that the primary task objectives could be met in the absence of supplemental information generated by the various site-specific tasks. However, since site-specific tasks are being completed, supplemental information will be used to further ensure that Task 44 objectives are met and that the overall RI objectives concerning surface and ground water at RMA are achieved. In order to maintain time-consistent analytical results, attempts have been made to coordinate all RMA ground-water tasks.

(b): Priority rankings were assigned subjectively by assessing the value or worth of each well based on the criteria listed on Page 6 of the Letter Technical Plan.

14. Comment:

Page 7, bottom of page: Wells should not be excluded from the network on the basis that their yield is low. In many areas of RMA (i.e., South Plants area) the sediments are relatively tight. Please explain what consideration these wells were given.

Response:

The only wells that were automatically excluded from the Task 44 network on the basis of low yield were wells that have previously not recharged sufficiently in 24 hours to allow a sample to be collected according to USATHAMA sampling protocol. Other low yield wells were excluded only if adjacent or nearby wells screened in the same water-bearing zones were available and had historically provided higher yields. Please refer also to our response to CDH Specific Comment 11.

15. Figure_2

- Where are the wells which are to be drilled off of the RMA?

- As the Boller well is questionable, why not use E-37 as an additional monitoring well?

- Insufficient wells off the Northwest Boundary will hamper the evaluation.

Response:

A location map with specific off-post wells (by task) is in the Composite Well Program Report. Site E37 is west of the Northwest Boundary System, far removed from the Boller well. Alluvial well 37344 is adjacent to the Boller well and is being sampled quarterly under Task 44. Task 44 will assess the need for wells off-post of the Northwest Boundary and make recommendations for drilling in future monitoring programs.

16. Comment:

Page 8, top of page: It is the position of Shell that the ranking system should have been reviewed with the MOA parties and it is requested that this be done.

Response:

Comment is well taken, and a discussion meeting will be scheduled in the near future.

17. Comment:

Page 8, second paragraph: The determination by the Program Manager of action levels appears to be in conflict with SARA. Also, the EA process has not involved the How Clean Is Clean subcommittee, and therefore, is not obtaining the input of other parties.

Response:

The second paragraph on page 8 refers to the use of guidance levels, not action levels. These guidance levels were used to focus the well selection process toward a network that would more effectively define contaminant distributions. The guidance levels are based on either state or federal regulatory criteria where available and are therefore not arbitrary determinations by the Program Manager. Only in the absence of such regulatory criteria are guidance levels developed on another basis. In the majority of cases where regulatory criteria are not available, guidance levels are designated as the method detection limit.

Although the Task 44 Letter Technical Plan was not meant to be a forum for discussion of the EA process, the comment concerning conflicts with SARA and input of other parties is unclear. Shell should provide additional information to clarify these statements.

18. Comment:

Page 9, top of page: Shell disagrees with the approach being used to select action levels. How can the Army indicate that the action levels will be within the same order of magnitude as the guidance levels in Task 44?

Response:

The method for determining action levels for the EA was not discussed in the Task 44 Letter Technical Plan; therefore, this comment needs further clarification. However, the Army does agree that it cannot be determined at this time whether action levels will be within the same order of magnitude as the guidance levels used in Task 44.

19. Comment:

Page 8, first paragraph: Isolated slugs of contamination resulting from fluctuation in the water table in the vicinity of the Northwest Boundary might also be a plausible explanation for inconsistent hits near the detection limit.

Response:

It is assumed that Comment 19 is directed toward the discussion presented on Page 9 rather than Page 8. Water-quality and water-quantity results obtained from previous RMA ground-water monitoring investigations have indicated that significant fluctuations in the water table are not apparent at RMA. The possibility of contaminant slugs is being investigated under boundary system tasks.

20. Comment:

Page 9: Wells with inconsistent analytical results should not be eliminated, especially when those results indicate that contaminant levels may be or have been very high. Many wells in the South Plants area fall into this category. If anything, these wells should be given extra consideration as they may represent proximity to source areas.

Response:

Wells with inconsistent analytical results were not necessarily eliminated from the network. Analytical result consistency was used only as a means of assessing the reliability of the water-quality data. Because of the variety of explanations that can be given for sporadic results, consistent trends were generally considered more reliable.

However, wells were not eliminated solely on the basis of inconsistent analytical results.

21. Comment:

Page 11, Figure 5: The inferred bedrock paleochannel map correlates well with the MKE interpretation, with the exception of Section 34. Drilling conducted in 1986 by MKE indicates that the small channel originating in Section 35 is not continuous through Section 34. The channel picks up again in the northwest quarter of Section 34.

Response:

The locations of inferred paleochannels shown on Figure 5 were established based on available geologic and hydrogeologic information. This map will be updated and revised accordingly as Task 44 interpretations are completed. These interpretations will incorporate data generated under Tasks 25, 26, 38, 39, and 44 and Shell investigations. Please refer also to our response to CDH Specific Comment 14.

22. Comment:

Figure 4: Does the saturated alluvium map represent a wet, dry, or average year? Both the high and low water table conditions need to be considered to insure unbiased selection of wells in areas where water level fluctuations produce periodic saturation of alluvial sediments.

Response:

The approximate areal extent of unsaturated alluvium presented in Figure 4 was constructed by modifying the unsaturated alluvium map presented in the Final Report, Selection of Contaminant Control Strategy for Rocky Mountain Arsenal (RMACCPMT, 1983). Modifications were made based on the results of the Task 4 water-quantity survey which consisted of four quarters of water-level measurement data. In general, the boundaries of unsaturated alluvium shown in Figure 4 were defined by wells periodically found to be dry during Task 4. Areas depicted as saturated contain Task 4 wells found to contain water consistently throughout the duration of Task 4. However, this map will be revised as additional data are generated and as further hydrogeologic interpretations are made.

23. Comment:

Page 12: The localized groundwater flow in Section 3 could be illustrated to depict the movement of the DBCP plume from the Rail Classification Yard in Section 3 to the Irondale Containment System in Section 33.

Response:

Ground-water flow directions shown on Figure 6 are based on the results of previous RMA hydrogeologic studies (May 1982) and recent (Task 4) water table contour maps. Flow directions were not drawn with inference to any previously identified contaminant distributions. Therefore, it would be inappropriate to depict the movement of DBCP contamination from the Rail Classification Yard to the Irondale Containment System as a localized ground-water flow direction in Figure 6.

24. **Comment:**

Page 13, first paragraph: We believe that the data is insufficient to allow the judgments which are being made relative to the depth of monitoring required.

Response:

Data resulting from evaluations of vertical contaminant distributions were used to assess only the maximum depths of contamination for each well cluster location. These evaluations were made by comparing all historical analyte concentrations available for each well in a given cluster to established RMA guidance levels. If nearby wells completed in vertically adjacent aquifer zones were not available, recommendations for installation of new Denver wells were made as a part of the Composite Well Program. If concentrations of contaminants above guidance levels are identified at the maximum depth of monitoring under Task 44, recommendations will be made for installation of wells in deeper aquifer zones and inclusion of these wells in the subsequent comprehensive long-term monitoring program.

25. **Comment:**

Page 17: More wells are needed in the North Plants area, Section 25. The currently proposed network does not adequately cover any potential migration from this important agent manufacturing site.

Response:

The need for additional monitoring wells in the North Plants area is being addressed as part of Task 42. Seven new wells are being installed in the North Plants area under Task 42, these wells will be considered for inclusion in future RMA regional ground-water monitoring programs. In addition, several new wells are proposed for installation in the area between North Plants and the North Boundary under the Composite Well Program. For example, a cluster of one alluvial well and two Denver wells has been installed at site EP74 as part of Task 44 in the south-central portion of Section 23. The need for additional monitoring wells in the North Plants area will be re-evaluated based on the results of Tasks 25, 36, 42, and 44.

26. Comment:

Page 19, first paragraph: Are there other lenticular sands that need to be checked? Shouldn't all the results from the well closure program be included before wells are selected for the Denver Formation?

Response:

A complete assessment of water-bearing zones in the Denver Formation will be made as Task 44 geologic and hydrogeologic interpretations are completed. The results of these interpretations will be presented in the Task 44 Final Report and will be used to guide future long-term monitoring investigations. The Task 44 interpretations will be made using data available on all existing wells at RMA including wells recommended for abandonment under the Well Closure Program.

27. Comment:

Page 19, second paragraph: This paragraph could be understood to imply that "three major hydrogeologic zones of the Denver" are found Arsenal-wide. This is not the case, and it should be clarified that all three of the described zones are only found in the Basin A/South Plants area. Also, a review of available data indicates that the tabular sand below the lignitic horizon ranges from 5 to 30 feet, not 50 feet as stated in the text.

Response:

Specific references to Denver lithologic units have been removed from the Task 44 Technical Plan and will be discussed in detail in the Task 44 Final Report.

28. Comment:

Table 6: It is recommended that the analytes include Army degradation compounds currently under certification. In addition, the Army should add other degradation compounds as they are certified.

Response:

Thiodiglycol is the most recent Army degradation compound for which an analytical method has been certified. Analytical methods that become certified for analysis of additional degradation compounds will be considered for inclusion in future long-term monitoring analytical programs.